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FINAL

REMEDIAL INVESTIGATION, BASELINE RISK ASSESSMENT, AND FEASIBILITY STUDY

EXECUTIVE SUMMARY

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

CONTRACT TASK ORDER 0084

NOVEMBER 17, 1994

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN PROGRAM
Contract N62470-89-D-4814

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1.0 INTRODUCTION

Baker Environmental, Inc. (Baker) was contracted to perform Remedial Investigation, Baseline Risk Assessment, and Feasibility Study activities for the Camp Allen Landfill Site under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Task Order Number 0084 (CTO-0084) for District III, Atlantic Division (LANTDIV), Naval Facilities Engineering Command. This Executive Summary of the Final Remedial Investigation, Baseline Risk Assessment, and Feasibility Study Reports presents a synopsis of primary site findings.

The objectives of the Remedial Investigation were to determine the extent and degree of contamination associated with two distinct areas, jointly referred to as the Camp Allen Landfill Site. These objectives were accomplished via investigation of subsurface soils, surface soils, sediment, surface water, groundwater, and air. A quantitative Baseline Risk Assessment evaluating current and potential future human health risks associated with these environmental media was completed, as was an ecological risk assessment. The information gathered and evaluated in the Remedial Investigation and the Baseline Risk Assessment formed the basis for the Feasibility Study, which assessed feasible alternatives for addressing/remediating adverse environmental impacts and potential hazards to human health identified at the site.

1.1 <u>Site History</u>

The Camp Allen area is located approximately one mile east of Hampton Boulevard and one mile south of Willoughby Bay (see Figure 1-1). Prior to 1940, this area was primarily occupied by surface water features related to Bousch Creek, which flows north into Willoughby Bay. Development of residential, commercial, and military related structures was limited to adjacent topographically high areas during this time period. In the late 1930s, these high portions of the Camp Allen area were reportedly used as soil borrow areas for development of other portions of Naval Base Norfolk. During the early 1940s, landfill operations commenced in the Camp Allen area (Camp Allen Landfill). Disposal activities continued until about 1974. The Camp Allen Landfill Site today is comprised of two distinct areas (Area A and Area B). Area A is a 45-acre site that was used primarily for the disposal of miscellaneous debris, metal plating and parts cleaning sludge, and various organic solvent-related residues. Additionally, ash from the incineration of solid wastes, as well as fly and bottom ash from the Naval Base power plant, were disposed.

In the mid-1940s, an incinerator was constructed in the southern portion of the Camp Allen area to burn combustible wastes. This incinerator operated until the mid-1960s. Materials too bulky for the incinerator were burned in Area A.

The eastern portion of the Camp Allen Landfill (Area B) received wastes from a 1971 Salvage Yard fire. The Camp Allen Salvage Yard, which is still in operation, is located between Camp Allen Landfill Areas A and B (see Figure 1-1). In general, Salvage Yard activities have included storage and management of waste oils and chemicals, over-age chemicals, and scrap industrial/commercial equipment. Also, miscellaneous incineration was a past practice and various recycling activities currently are performed at the facility. The residue and debris remaining after the 1971 Salvage Yard fire were buried in an adjacent area (Area B) via trench and fill operations.

At present, the majority of Area A and Area B are soil covered and revegetated to minimize surface erosion. Area A incorporates the Navy Brig Facility and a heliport built over a portion of the landfill in the mid-1970s. Glenwood Park (an off-base residential area) is located to the west of Area A and Camp Allen Elementary School is located to the south of Area B. The Capehart Military Housing Area is located south of the Camp Allen Elementary School. Various military activities, including USMC Camp Elmore operations, are conducted throughout the Camp Allen area.

1.2 Previous Investigations

Previous investigations of hazardous waste sites at the Norfolk Naval Base (including the Camp Allen Landfill) have been conducted and/or documented in an Initial Assessment Study, Site Suitability Assessment Study, Confirmation Study, an Interim Remedial Investigation Report, and an Interim Remedial Investigation of the Camp Allen Landfill Site:

- Initial Assessment Study (Malcolm Pirnie, Inc., February 1983): Based on review of historical records and general site reconnaissance, the Camp Allen Landfill was among the sites at the Norfolk Naval Base recommended for further study.

- Site Suitability Assessment (Malcolm Pirnie, Inc., June 1984): Assessment activities were conducted for a proposed Brig Expansion. Magnetometer data indicated extensive areas of buried metallic objects throughout the middle and southern portions of Area A. Shallow groundwater samples identified the area west of the Brig Facility as having organic pollutants (i.e., trichloroethylene, benzene, and toluene) and certain metals (i.e., arsenic, cadmium, lead, and zinc) in concentrations that exceeded USEPA water quality criteria.

- Confirmation Study (Malcolm Pirnie, Inc., June 1983): Analysis of organic compounds in water table aquifer groundwater samples from two general locations (Area A [west of Brig] - 3 wells; Area B [northeast portion] - 3 wells) identified elevated concentrations (exceeding applicable water quality criteria/standards) of several volatile organics (i.e., vinyl chloride, trichloroethylene, toluene). No organic compounds were detected in the Yorktown aquifer groundwater in limited sampling. Leaching of organic compounds (i.e., vinyl chloride, trichloroethylene) directly east of Area B into the drainage and ponded surface waters was confirmed. Cadmium, chromium, lead, and zinc exceeded applicable water quality criteria in unfiltered groundwater and surface water samples.

- Interim Remedial Investigation Report (Malcolm Pirnie, Inc., March 1988): This interim report summarized Confirmation Study results for the Camp Allen Landfill. Additional field activities were not performed.

- Interim Remedial Investigation (CH2M Hill, 1990-1991): This investigation noted the following:

    - The confining clay unit which separates the water table and Yorktown aquifers, appeared to be absent in various locations, allowing for potential downward migration of contaminants from the landfill.

    - Samples from 27 shallow wells at Areas A and B confirmed organic compounds (vinyl chloride, trichloroethene, and 1,2-dichloroethene) in the shallow groundwater in two general locations (Area A - west of Brig Facility and southeast of Area B) exceeding applicable water quality criteria/standards.

- Samples from nine deep wells at Areas A and B confirmed the same organic compounds (vinyl chloride, trichloroethene, and 1,2-dichloroethene) in the deep groundwater samples from three general locations (Area A - west and north of the Brig Facility and southeast of Area B) exceeding applicable water quality criteria/standards.

- Leaching of organic compounds (i.e., vinyl chloride, trichloroethene, 1,2-dichloroethene) into surface water and sediments was confirmed directly east of Area B into the drainage ditch sediments and ponded surface waters.

- Inorganic compounds (arsenic, cadmium, chromium, lead, and zinc) in sediments north of Area A exceeding applicable sediment quality criteria.

- Volatile organic compounds did not appear to be migrating west from Area A beyond the perimeter drainage ditch, as they were absent in 55 residential, nonpotable, shallow wells in Glenwood Park.

In part, these results guided the scoping of the Remedial Investigation summarized in this document, and have been incorporated into this study's interpretations, as appropriate.

SECTION 1.0 FIGURES

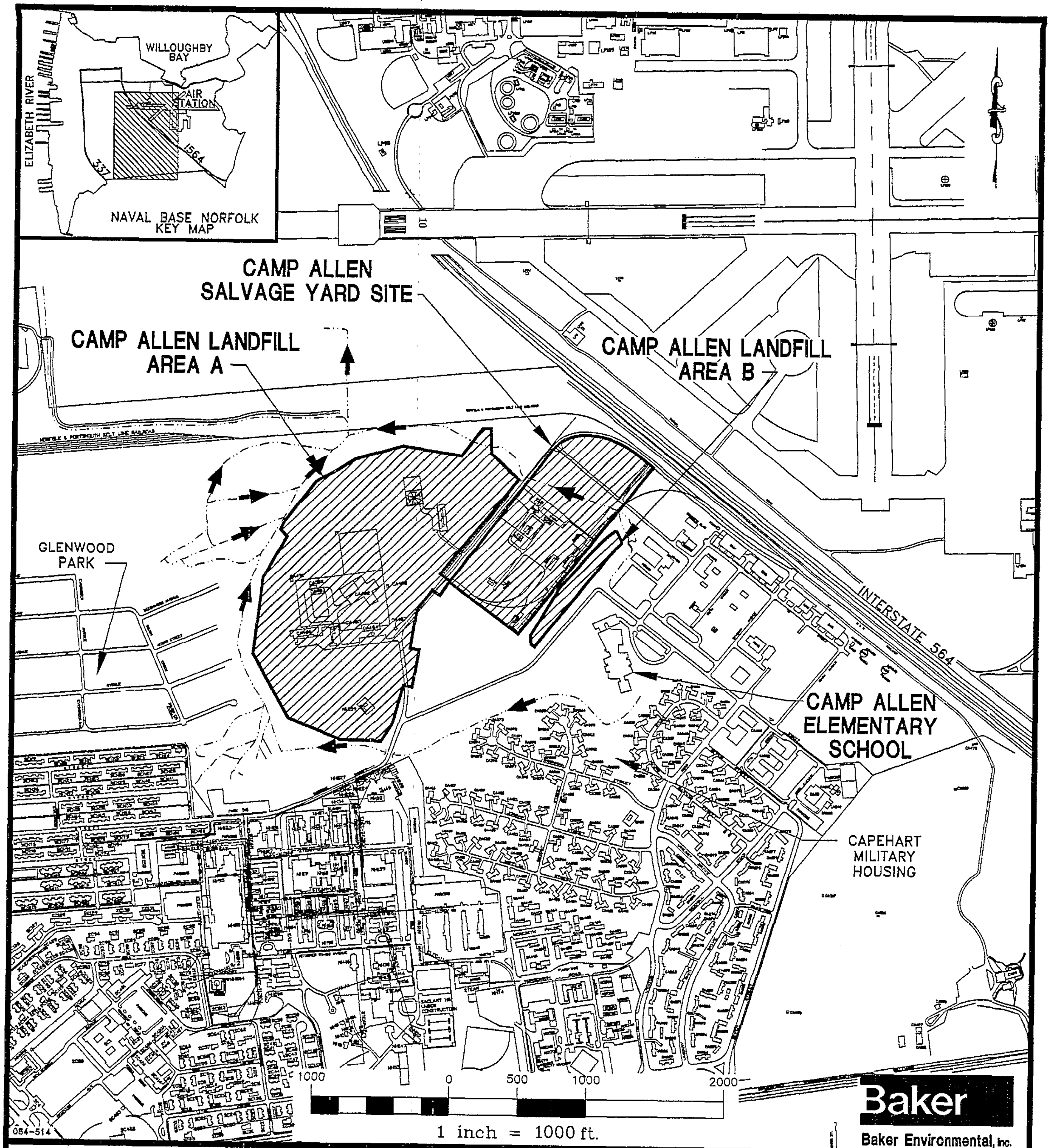


FIGURE 1-1
SITE LOCATION MAP
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

SOURCE: LANTDIV, OCTOBER 1991

2.0 REMEDIAL INVESTIGATION FIELD ACTIVITIES

The primary objectives of the Remedial Investigation (RI) at the Camp Allen Landfill Site were to identify and evaluate the physical and chemical characteristics of the Camp Allen area. Field activities performed in and around the Camp Allen Landfill were designed to adequately describe site topography, subsurface geology, hydrogeologic features, primary waste characteristics, and the nature and extent of constituent migration resulting from past disposal practices at the Camp Allen Landfill.

Field activities were conducted at the Camp Allen Landfill Site as three separate events (designated as Rounds 1, 2, and 3):

- Round 1 primarily consisted of field verification sampling to help select/finalize proposed sampling locations (i.e., monitoring well locations);
- Round 2 consisted of a comprehensive round of sampling of subsurface soil, surface soil, sediment, surface water, and groundwater;
- Round 3 was performed to fill additional data needs identified from a preliminary evaluation of Round 2 data, and included an air sampling program.

An overview of the RI activities follows. Remedial Investigation sampling points at Area A and Area B of the Camp Allen Landfill are presented on Figure 2-1. Glenwood Park residential well locations from which groundwater samples were collected during 1991 and 1992 are presented in Figure 2-2.

2.1 <u>Overview of Area A RI Activities</u>

Field activities conducted at Area A included:

- Geophysical survey (electromagnetometer, resistivity sounding, and downhole gamma logging)

- Monitoring well installation (ten wells installed in the Yorktown aquifer; one well installed in the water table aquifer; and, one 4-inch pumping well and one 2-inch piezometer installed in the Yorktown aquifer)

- Surface soil sampling (five locations)

- Source characterization (eight subsurface soil sample locations)

- Surface water and sediment sampling (11 surface water and 31 sediment sample locations)

- Geologic borings (11 locations)

- Residential well groundwater sampling - two locations to complement previous sampling by CH_2M Hill at 55 locations

- Groundwater sampling (three separate rounds)

- Aquifer testing (pumping test from the pumping well and slug tests at 10 locations)

- Air sampling (12 locations in the Brig Facility and five ambient air locations)

- Land surveying (investigative points and primary surface features)

2.2 Overview of Area B RI Activities

Field activities conducted at Area B included:

- Geophysical survey (electromagnetometer and ground penetrating radar)

- Geoprobe investigation (in-situ groundwater sampling [water table aquifer])

- Monitoring well installation (four installed in the Yorktown aquifer and eight installed in the water table aquifer)

- Surface soil sampling (eight locations)

- Source characterization (ten subsurface soil sample locations)

- Surface water and sediment sampling (five surface water and eight sediment sample locations)

- Groundwater sampling (three separate rounds)

- Aquifer testing (slug tests at nine locations)

- Air sampling (five locations at the Camp Allen Elementary School)

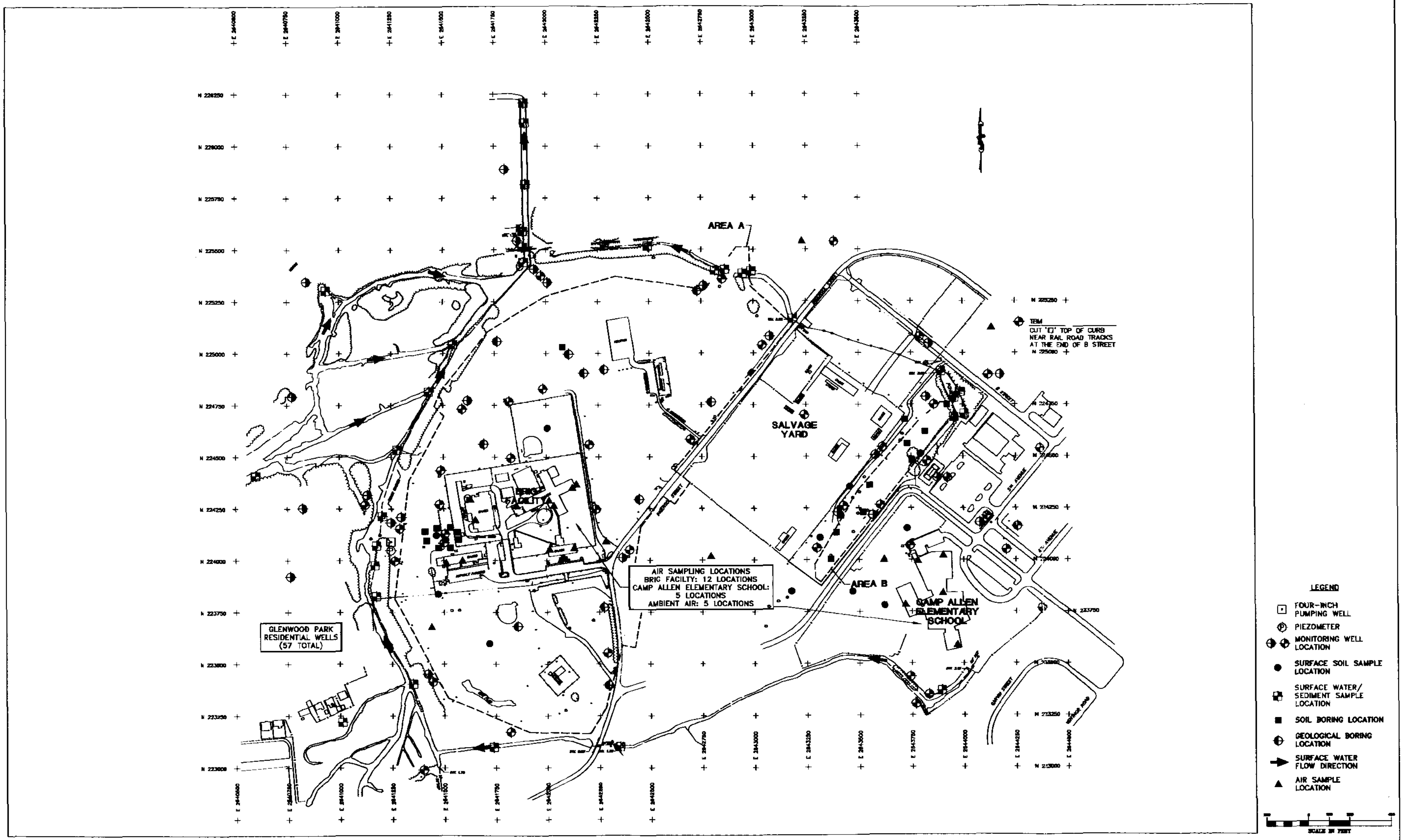
- Land surveying (investigative points and primary surface features)

The various media sampled at the Camp Allen Landfill were selectively analyzed for volatile organic compounds, semivolatile organic compounds, pesticides/PCBs, and inorganic compounds including total and dissolved fractions, as appropriate. Select samples/media were also analyzed for indicator parameters such as alkalinity, total suspended solids, and total organic content. Analyses were performed under Naval Energy and Environmental Support Activity (NEESA) and Contract Laboratory Program (CLP) protocol. In addition, NEESA Level D quality assurance was followed. In the case of air sample analysis, EPA Compendium Method TO-14 was used as volatile organics were the primary constituents of concern. Analytical reports from the NEESA/CLP-approved laboratory were submitted to an independent data validator to evaluate the usability of the analytical data. Based on information contained in the Data Validation Reports, the analytical results for the samples collected at the Camp Allen Landfill are considered representative of site conditions.

2.3 Overview of Ecological Assessment

An ecological investigation was performed in June 1993 and included benthic sampling in the Area A drainage ditches and Area B pond, as well as observations of aquatic and terrestrial flora and fauna. An ecological risk assessment (ERA) subsequently was conducted for Camp Allen and surrounding areas to evaluate the impacts of the Camp Allen Landfill on terrestrial and aquatic habitats on or adjacent to the site. The ERA incorporates the results obtained from the surface water and sediment sampling conducted as part of the remedial investigation at the Camp Allen Landfill. This assessment also evaluated the potential effects of contaminants from the site on sensitive environments, including wetlands, protected species, and valuable or critical habitats. The conclusions of the ERA (summarized in Section 3.3) were used in conjunction with the human health risk assessment to determine the appropriate remedial action at this site for the overall protection of public health and the environment.

SECTION 2.0 FIGURES



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NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

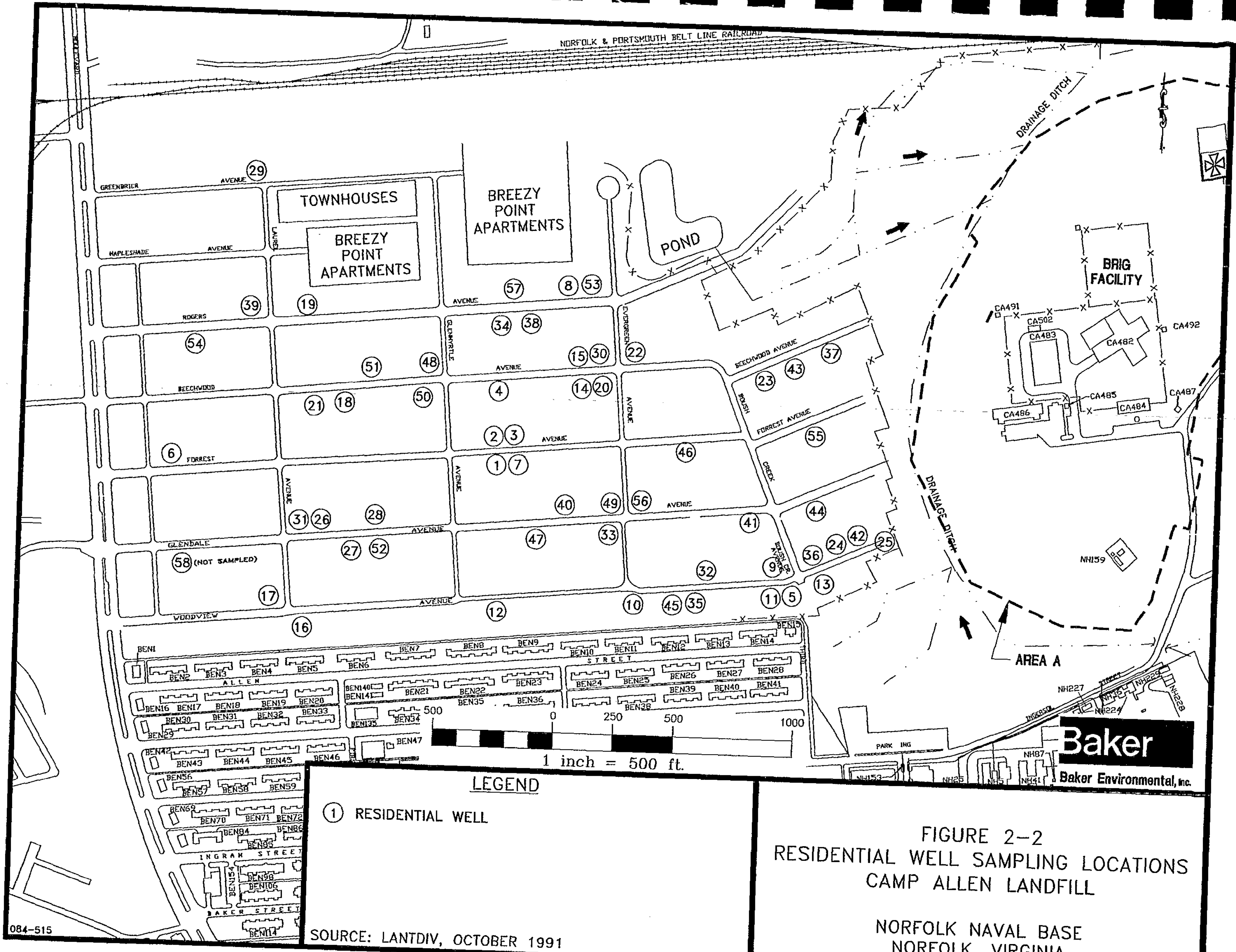
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

REMEDIAL INVESTIGATION
SAMPLING POINTS

SCALE GRAPHIC DATE 7/93

FIGURE
2-1



LEGEND

① RESIDENTIAL WELL

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 2-2
RESIDENTIAL WELL SAMPLING LOCATIONS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

3.0 REMEDIAL INVESTIGATION FINDINGS

3.1 Geology/Hydrogeology

Site lithology of the Camp Allen area consists of three primary strata: (1) silts, clays, and sands of the Columbia Group ranging from 0 to 27 feet below ground surface (bgs) or deeper; (2) a confining clay layer at the base of the Columbia Group (locally absent) ranging from 25 to approximately 40 feet bgs; and/or, (3) a silt/sand/shell hash unit (Yorktown Formation) ranging from about 40 to 130 feet bgs, where it abruptly contacts the St. Mary's "blue bed" of the Calvert Formation.

Two aquifer systems are impacted by the Camp Allen Landfill: the water table aquifer (Columbia Group) and the underlying Yorktown aquifer (Yorktown Formation). The water table aquifer (shallow groundwater) is unconfined, with an average water level of six feet bgs, a flow direction that typically mirrors surface topography, and an average flow velocity of 0.6 to 1.2 feet per day. The Yorktown aquifer (deep groundwater) is separated from the water table aquifer by the confining clay unit noted above. A breach and/or ineffective (poorly developed) leaky portion of the confining clay unit allow downward migration of constituents from the surficial aquifer and the Camp Allen Landfill. Groundwater flow in the Yorktown aquifer is primarily to the northwest at an average velocity of 0.001 to 0.08 feet/day.

To visualize site conditions, two generalized depictions have been developed. Figure 3-1 presents generalized groundwater flow patterns for both the water table and Yorktown aquifer systems. Figure 3-2 presents a conceptualized cross-section indicating generalized contaminant migration from the Camp Allen Landfill.

3.2 Nature and Extent of Contamination

Contamination from prior disposal practices at Areas A and B of the Camp Allen Landfill have impacted subsurface soils, surface soils, sediment, surface water, and groundwater (water table and Yorktown aquifer systems). Constituents of concern are volatile organic compounds (VOCs) and various inorganic elements; Table 3-1 lists primary areas of detected contamination by media and area. Highlights include source areas of VOCs in subsurface soils identified at or near the top of the water table aquifer in Area A and Area B. In isolated locations, wastes were identified beneath the water table.

Contamination likely attributable to off-site sources has also been identified. Potential off-site sources of contamination are indicated in the Salvage Yard area, located between Areas A and B, and in the Capehart Military Housing area, south of the Camp Allen Elementary School. Table 3-1 also notes these potential off-site contamination sources.

3.2.1 Area A

3.2.1.1 Subsurface Soil

As shown on Figure 3-3, volatiles and semivolatiles related to solvents and fuel oils were detected in Area A and B subsurface soils. At Area A, volatile organic compounds were detected at significant concentrations in five samples at or below the top of the shallow aquifer, and are considered the primary constituents of concern. These volatiles reflect disposal of waste solvent or fuel oil-laden materials. Two primary suspected source areas of volatile constituents have been identified at Area A (Figure 3-3).. Semivolatiles appeared more prevalent in samples containing higher concentrations of volatiles. Pesticide compounds were detected at concentrations that would suggest that the occurrence and distribution is related to typical controlled applications. Since metals were not a suspected contaminant in Area A soils, based on previous investigations, they were not investigated in this RI.

3.2.1.2 Surface Soil

No volatiles other than common laboratory contaminants were detected in Area A surface soils. Semivolatile constituents and their concentrations were analogous for surface soils collected at the Area A landfill.

Pesticide compounds were detected throughout surface soils in Area A in trace amounts. In addition to 4,4'-DDT and the associated breakdown compounds found in both areas; dieldrin was detected more often in Area A. Detected pesticide compounds are likely due to typical land application.

Arsenic and lead were consistently present in surface soils in Area A. Cadmium, copper, and zinc were commonly found in Area A surface soils. Although detected concentrations in some cases exceeded background criteria, significant inorganic source areas are not indicated.

3.2.1.3 Sediment

Since a singular surface drainage system encompasses Camp Allen Areas A and B, sediments are considered jointly for the two areas. Sediment in the drainage ditches surrounding Areas A and B was found to contain localized elevated levels of organic and inorganic constituents (see Figure 3-3).

Volatile organic compounds were detected in sediment samples from the southern portion of the ponded area (Area B) and to the north and northwest (downstream) at the culvert discharging into the drainage ditch at the northeast portion of Area A. From this point on (downstream), volatile compound constituents decreased significantly. Volatile compounds detected in sediment samples correlate with compounds detected in surface water and groundwater. This suggests that contaminants may be migrating with surface water from Area B and either volatilizing, degrading, or being deposited with the sediment. This indicates that contaminants in the source area (Area B) are migrating with groundwater and being discharged into the surface water via seeps along the ponded area of the landfill.

Semivolatile organic compounds detected and their respective concentrations were somewhat similar for Area A and Area B sediments. Two areas impacted by these constituents were the shallow and deep sediments in the northern portion of the ponded area and the discharge point from Area B to Area A (northeast portion of Area A).

Pesticide/PCB compounds were present in sediments throughout Areas A and B. 4,4'-DDT and its breakdown components were analogous at Area A and Area B, with the most significant concentration in the ponded area. PCB contamination was noted in the shallow sediment at the center of the ponded area.

The semivolatile organics and pesticide/PCB compounds detected in drainage ditch sediments in Area A mirrored those found in the surface soils, suggesting surface particulate runoff and particle deposition in the drainage ditches as another potential contaminant migration mechanism.

Five metals (arsenic, cadmium, chromium, lead, and mercury) were analogous to Area A and Area B, with the highest concentrations detected in Area A. Metal concentrations fluctuated with sediment depth, depending on location. Although several of the metals detected exceeded sediment quality criteria throughout Area A drainage ditches, no direct trends are apparent. Given the history of incineration activities/incinerator ash disposal which occurred in the Camp Allen area, metals in drainage ditch sediments could reflect past transport via surface water runoff before the landfill was closed. Given that the Area B pond is adjacent to the Salvage Yard, it represents another potential source of contaminants.

3.2.1.4 Surface Water

Since a singular surface drainage system encompasses Areas A and B, surface waters are considered jointly for the two areas. Surface water in Area A drainage ditches contained no more than traces of volatile compounds. Surface water in the pond at Area B contained volatile organics trending similarly to the sediment volatiles (see Figure 3-3).

Semivolatile organic and pesticide/PCB compounds were either absent or detected in concentrations well below Federal or State standards in Areas A and B surface waters.

Total metal concentrations detected in surface water samples from Areas A and B including chromium, iron, lead, mercury, and nickel exceeded Ambient Water Quality Criteria (AWQCs) in isolated locations. Additional metals (total) were detected; however, the occurrence and distribution can be considered typical for surface water.

3.2.1.5 Shallow Groundwater

Areas of shallow groundwater contamination identified during RI activities are presented in Figure 3-4. The shallow groundwater at Area A contained concentrations of VOCs exceeding applicable water quality standards west of the Brig Facility. This is at and/or adjacent to one or more suspected source areas. Volatile contaminants include solvent-related compounds, ketones and BTX compounds.

A second potential source area of VOCs -- low concentrations of solvent-related compounds -- was identified north of the Brig Facility, in the northeastern part of Area A. This source area is believed to extend west towards the helipad area.

Semivolatile constituents in shallow groundwater were primarily phenol and phenolic compounds. Only trace amounts of phenol and other semivolatile compounds (such as phthalates) were found in the shallow groundwater at Area A.

Pesticides detected at scattered well locations in Area A likely reflect regional, sporadic concentrations rather than site-specific causes.

A number of inorganic constituents were detected in groundwater samples collected from the water table aquifer in concentrations exceeding state and Federal drinking water standards throughout the site. However, based on comparisons of total versus dissolved metal concentrations and linear regression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of concern (e.g., arsenic, chromium), the inorganic contaminants detected in the groundwater are believed to be attributable to suspended solids present in the wells, and are not considered to reflect actual groundwater contamination.

3.2.1.6 <u>Deep Groundwater</u>

Areas of contamination identified in the Yorktown aquifer are presented in Figure 3-4. Both organic and inorganic constituents were identified. Contamination in the deep aquifer at Area A shows two areas of elevated volatile organic concentrations - west of the Brig Facility and north of Area A. Trace concentrations were also found further to the west of Area A, downgradient of the highly affected areas. Groundwater in the lower portion of the deep (Yorktown) aquifer was found to contain minor concentrations of volatile constituents.

Semivolatile compounds in the deep aquifer at Area A were found at trace levels west of the Brig Facility, west of Area A and east of the Brig Facility. Compounds detected include phenol, ethers, PAHs and phthalates. No semivolatile compounds were detected in the wells screened in the lower part of the deep aquifer.

Pesticides in the deep groundwater were detected only along the eastern border of Area A. These are east of the Brig Facility and adjacent to the Salvage Yard, respectively. These detected pesticides may be related to regional concentrations of pesticides in the Yorktown aquifer as source characterization activities did not identify consistent appreciable detections of pesticide compounds.

Total inorganic constituents were detected in groundwater samples collected from the Yorktown aquifer in concentrations exceeding state and Federal drinking water standards throughout the site. However, based on comparisons of total versus dissolved metal concentrations and linear regression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of concern (e.g., arsenic, chromium), the inorganic contaminants detected in the groundwater are believed to be associated with total suspended solids present in the well and not representative of actual groundwater contamination.

3.2.2 Area B

3.2.2.1 Subsurface Soil

In Area B, solvent and fuel oil type volatile contaminants have also been identified (see Figure-3-3) at three locations just above the water table. One area of significantly higher volatile concentration (northeastern portion of Area B) is of particular concern. Semivolatiles were more prevalent at areas containing higher concentrations of volatiles. Pesticide/PCB compounds were nonexistent in subsurface soils with the exception of one location in the northeastern portion of Area B which contained significant concentrations.

Four metals (chromium, lead, manganese, and zinc) were prevalent throughout the subsurface soils in Area B. High concentrations of inorganic compounds were noted at only one boring location in the southwestern corner of Area B, adjacent to the Salvage Yard. Geophysical survey results indicated this to be a suspected disposal area containing "pockets of metallic fill material surrounded by high conductivity nonmetallic fill." Given that incineration was once performed in the Camp

Allen area and that soil borrow pits in the vicinity were reportedly used for "landfill capping," elevated metal concentrations in the subsurficial soils at Area B would be anticipated.

3.2.2.2 Surface Soil

No volatiles other than common laboratory contaminants were detected in Area B surface soils. Semivolatile constituents and their concentrations were analogous for surface soils collected at the Area B landfill.

Pesticide compounds were detected throughout surface soils in Area B in trace amounts. In addition to 4,4'-DDT and the associated breakdown compounds found in both areas; alpha-chlordane was detected more often in Area B. Detected pesticide compounds are likely due to typical land application.

Arsenic and lead were consistently present in surface soils in Area B. Aluminum, cadmium, and iron were commonly found in Area B soils. Although detected concentrations in some cases exceeded background criteria, significant inorganic source areas are not indicated.

3.2.2.3 Sediment

Section 3.2.1.3 discusses sediment conditions in the singular surface drainage system that encompasses Areas A and B.

3.2.2.4 Surface Water

Section 3.2.1.4 discusses surface water conditions in the singular surface drainage system that encompasses Areas A and B.

3.2.2.5 Shallow Groundwater

VOCs at Area B show the highest concentrations southeast of Area B, along (or adjacent to) utility conduits beneath C Street. Constituents include solvent-related compounds, BTX, ketones and chlorobenzene.

Elevated concentrations of volatiles, consisting primarily of solvent-related compounds, were also noted south of the Camp Allen Elementary School (CAES). These compounds appear to be preferentially migrating from Area B along existing utility trenches/lines along the eastern portion of the CAES, toward the south.

Semivolatile constituents in Area B shallow groundwater were varied, and included not only phenols and phthalates, but also PAHs, ethers and dichlorobenzenes. Highest concentrations of these contaminants occur just north of CAES.

Pesticides were detected in western and southeastern Area B at concentrations exceeding MCLs. Those found southeast of Area B may reflect either off-site or regional background influence, as no other groundwater contamination was noted in that area.

A number of inorganic constituents were detected in groundwater samples collected from the water table aquifer in concentrations exceeding state and Federal drinking water standards throughout the site. However, based on comparisons of total versus dissolved metal concentrations and linear regression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of concern (e.g., arsenic, chromium), the inorganic contaminants detected in the groundwater are believed to be attributable to suspended solids present in the wells, and are not considered to reflect actual groundwater contamination.

3.2.2.6 Deep Groundwater

Volatile organic compounds in the deep aquifer at Area B show a different trend than in the shallow aquifer at Area B. The highest total volatile concentrations were found along the southeastern portion of Area B. Concentrations decrease significantly to the northeast. This may be due to the location of the source area noted in the geophysical investigation at the southeastern portion of Area B where the confining clay layer was found to be absent or not well developed.

Regarding semivolatile compounds at Area B, only phenol was detected in the deep groundwater. These were detected at the same locations where high concentrations of volatile compounds were observed.

Pesticides in the deep aquifer at Area B were found primarily northeast and southeast of Area B at two isolated locations. Detected concentrations may be indicative of regional background concentrations.

Total inorganic constituents were detected in groundwater samples collected from the Yorktown aquifer in concentrations exceeding state and Federal drinking water standards throughout the site. However, based on comparisons of total versus dissolved metal concentrations and linear regression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of concern (e.g., arsenic, chromium), the inorganic contaminants detected in the groundwater are believed to be associated with total suspended solids present in the well and not representative of actual groundwater contamination.

3.2.3 Air

Based on results of the Air Sampling Program performed at the Brig Facility and the Camp Allen Elementary School, no significant site-specific volatile air contaminants were detected.

3.3 Ecological Assessment

The ecological assessment was performed to evaluate the impacts of the Camp Allen Landfill on terrestrial and aquatic habitats on or adjacent to the site. The ecological assessment included collection of physical water quality data, sampling and analysis of benthic macroinvertebrates, and qualitative evaluation of the terrestrial environment.

In most cases, physical water quality measurements (pH, salinity, dissolved oxygen, etc.) were within the ranges expected for waters in urban drainageways and reflective of natural conditions.

Benthic macroinvertebrates were present in every benthic sample; populations in all samples appeared to be healthy. The number of individuals and taxa represented indicate that a healthy environment for such organisms exists at Camp Allen.

The terrestrial environment also appeared to be unaffected by site contaminants. Gross effects of contamination (i.e., death or illness of wildlife, vegetative stress) were not observed. Habitats appeared to be diverse and included species to be expected, particularly in an urban environment. Wildlife was breeding and reproducing on site and natural processes like habitat succession indicated that plants were germinating and competing successfully.

3.4 Summary

Following is a summary of findings at the Camp Allen Landfill Site:

Area A

- Source characterization: VOCs were the predominant contaminants detected in the subsurface soils at Area A. In general, two primary source locations were indicated. The first area appears to be located in the western vicinity of the Brig Facility. The second potential area appears to be located towards the northern/northeastern region of Area A.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate isolated areas of various inorganic constituent concentrations exceeding applicable standards/criteria. General background constituent concentrations for the entire Norfolk Naval Base area are relatively high as well.

- Sediment: Results indicate isolated areas of various inorganic constituent concentrations exceeding applicable criteria. Inorganic contamination could be present in small, sporadic areas of the drainage ditches surrounding the area. Relatively high background constituent concentrations are apparent.

- Groundwater: Two primary areas of VOC contamination were identified at Area A. The first area is located towards the western portion of the Brig Facility and the second area is located along the north portion of the site. Both shallow and deep groundwater contamination is present within these areas. Identified contaminants appear to correspond to source areas mentioned above.

- Residential well groundwater sampling: Analytical results indicate that site-related contaminants have not impacted the shallow (water table) groundwater in the Glenwood Park area. Shallow groundwater contamination appears to be limited to the western side of the Brig Facility (located east of Glenwood Park).

- Air sampling: No significant site-specific volatile air contaminants were detected.

<u>Area B</u>

- Source characterization: VOCs were the predominant contaminants detected in the subsurface soils at Area B. In general, the primary source area is located in the middle portion of the site within the landfill.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate areas of various VOC and inorganic constituent concentrations exceeding applicable standards/criteria primarily in the eastern and northern portion of the ponded area.

- Sediment: Results indicate isolated areas of various VOC and inorganic constituent concentrations exceeding applicable criteria. Contamination could be present in areas of the ponded drainage way northeast of the site.

- Groundwater: One primary area of VOC contamination was identified at Area B. This area is located in the vicinity of the landfill, as well as near the southern border of the site, directly south of the Camp Allen Elementary School. Both shallow and deep groundwater contamination is present within this area. Identified contaminants correspond to the source area within the Area B landfill mentioned above.

- Residential wells: No residential wells are reportedly located in the vicinity of Area B.

- Air sampling: No significant site-specific volatile air contaminants were detected.

SECTION 3.0 TABLES

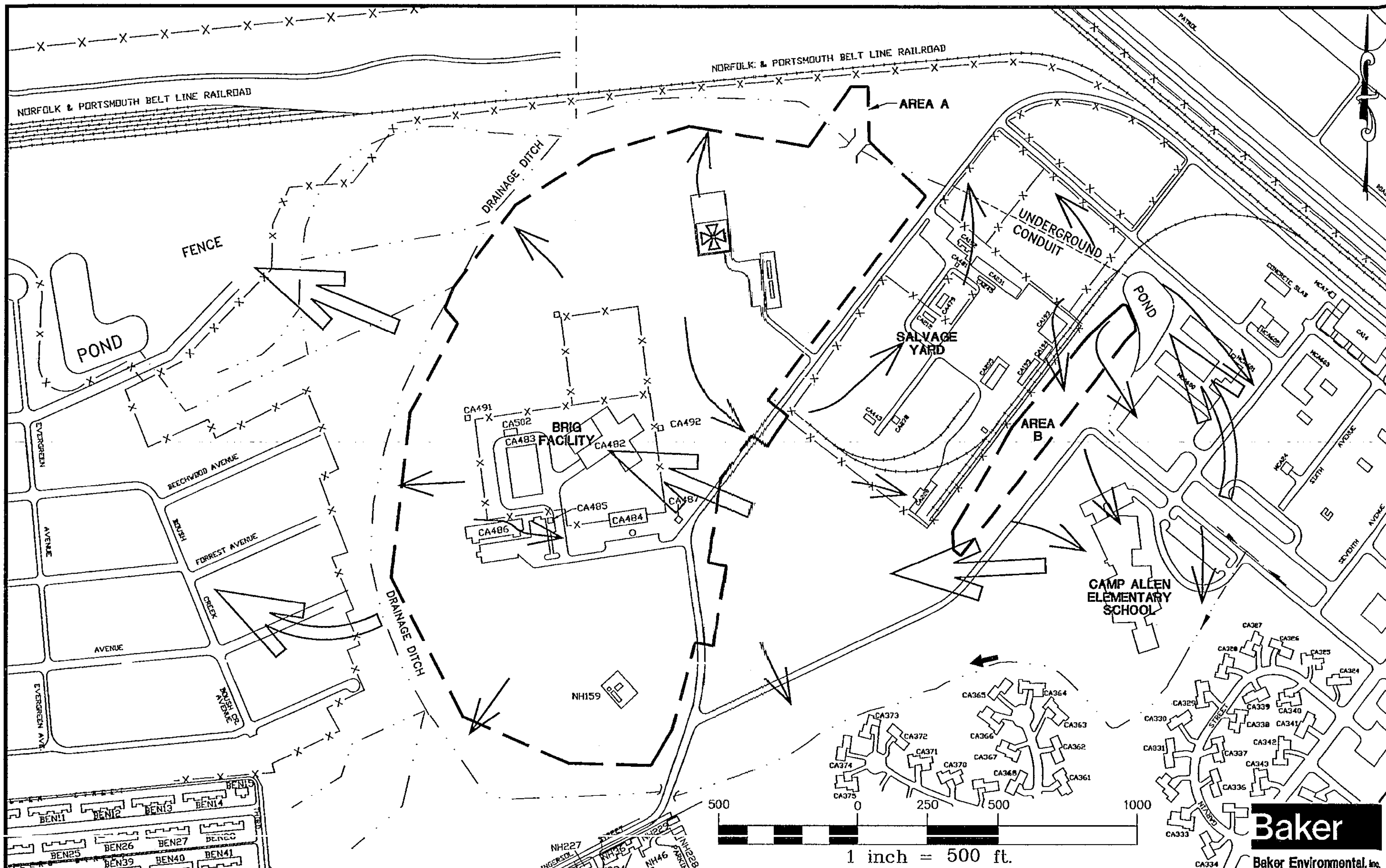
TABLE 3-1

SUMMARY OF RI FINDINGS

<table>
<tr><th>Media</th><th>Area A</th><th>Area B</th></tr>
<tr><td>Subsurface Soil</td><td>VOCs
● West of Brig Facility
● North of Brig Facility</td><td>VOCs
● Middle portion of Area B</td></tr>
<tr><td>Surface Soil</td><td>Nominal findings</td><td>Nominal findings</td></tr>
<tr><td rowspan="2">Sediment</td><td>VOCs
● Northwest drainage ditch (Area B related)</td><td>VOCs
● Ponded area</td></tr>
<tr><td>Metals
● Northeast drainage ditch (Area B related) (various constituents)
● Northern drainage ditch (various constituents)
● Northwestern drainage ditch (mercury plus others)</td><td>Metals
● Ponded area* (mercury plus others)</td></tr>
<tr><td rowspan="2">Surface Water</td><td>VOCs
● Northwest drainage ditch (Area B related)</td><td>VOCs
● Ponded area</td></tr>
<tr><td>Metals
● Throughout Area A* (various constituents)</td><td>Metals
● Ponded area*
● Throughout drainage ditches*</td></tr>
<tr><td>Shallow Groundwater</td><td>VOCs
● West of Brig Facility
● North of Brig Facility</td><td>VOCs
● South/southeast of Area B
● Capehart Military Housing Area*</td></tr>
<tr><td>Deep Groundwater</td><td>VOCs
● West of Brig Facility
● North of Brig Facility</td><td>VOCs
● Underneath Area B</td></tr>
</table>

*Potential off-site source.

SECTION 3.0 FIGURES



LEGEND

ASSUMED LANDFILL BOUNDARY

GENERAL DEEP GROUNDWATER FLOW DIRECTION (YORKTOWN AQUIFER)

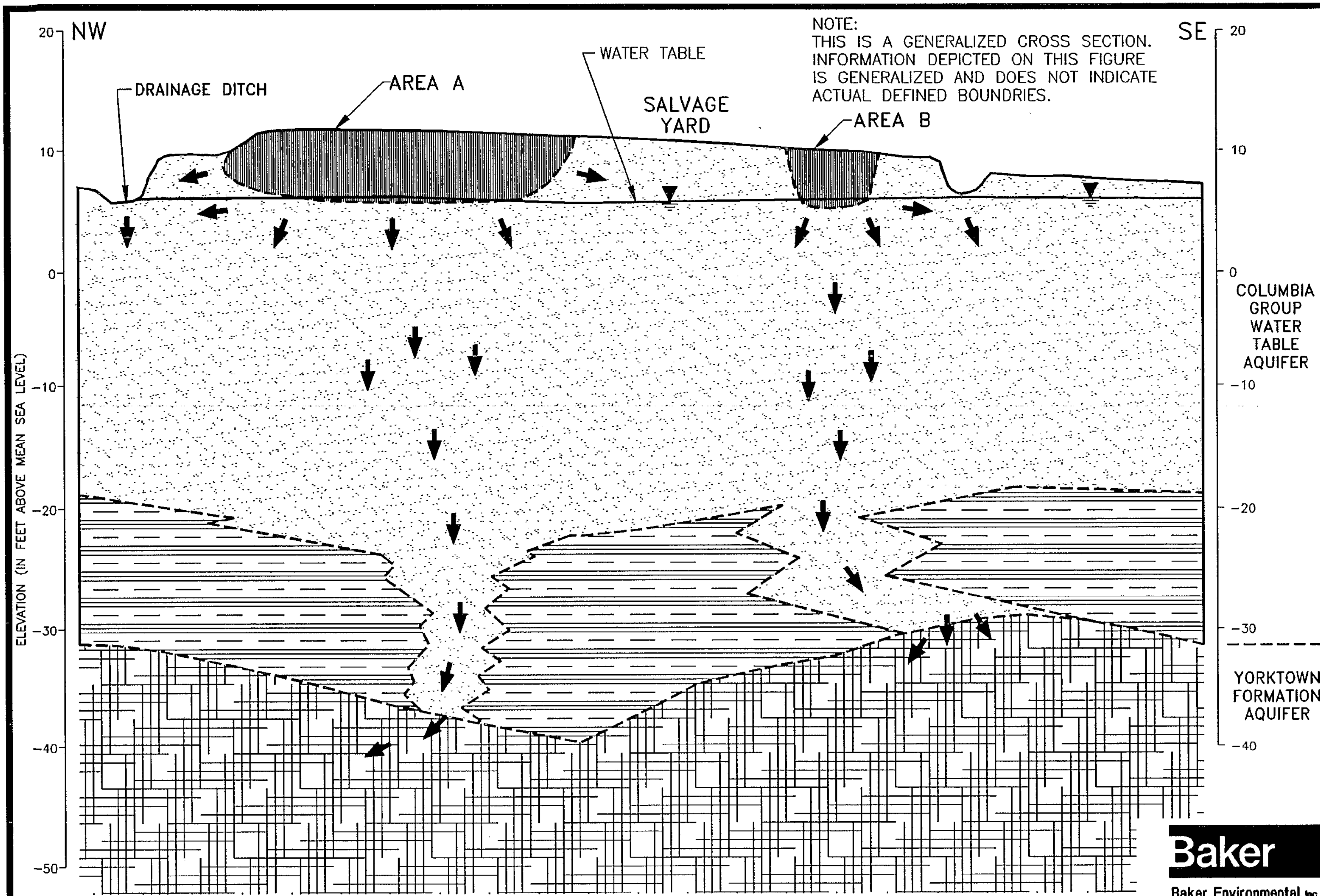
GENERAL SHALLOW GROUNDWATER FLOW DIRECTION (WATER TABLE AQUIFER)

NOTE: INFORMATION DEPICTED ON THIS FIGURE IS GENERALIZED AND DOES NOT INDICATE ACTUAL DEFINED PATTERNS.

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 3-1
GENERAL GROUNDWATER FLOW PATTERNS
CAMP ALLEN LANDFILL AREAS A & B

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



300 0 150 300

1 inch = 300 ft.
HORIZONTAL SCALE

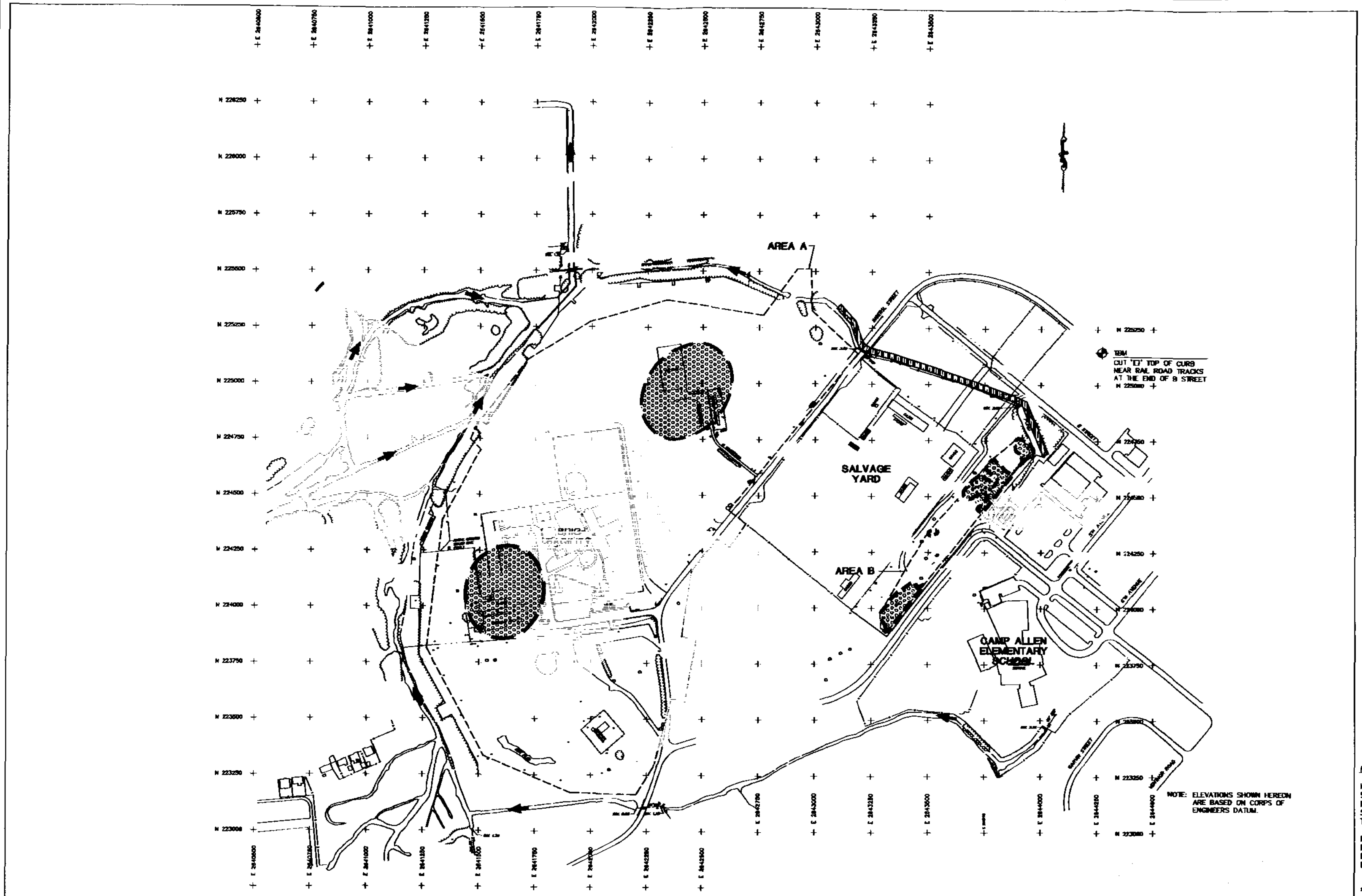
VERTICAL EXAGGERATION ±20x

084-517

LEGEND

- FILL
- CONTAMINATION MIGRATION
- SILTY AND CLAYEY SANDS (COLUMBIA GROUP)
- CLAY WITH LITTLE SILT, SAND (CONFINING UNIT: BREACHED AT PLACES)
- SILTY SANDS WITH SHELLS (YORKTOWN FORMATION)

FIGURE 3-2
GENERALIZED CONTAMINATION MIGRATION
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

- SUSPECTED SOURCE LOCATION
- SEDIMENT AND SURFACE WATER ORGANICS
- CLAY BREECH
- SURFACE WATER FLOW DIRECTION

NOTES:

INORGANICS WERE DETECTED IN SPORADIC CONCENTRATIONS IN SEDIMENTS AND SURFACE WATER THROUGHOUT THE DRAINAGE DITCHES.

INFORMATION DEPICTED ON THIS FIGURE IS GENERALIZED AND DOES NOT INDICATE ACTUAL DEFINED BOUNDARIES.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-518	

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

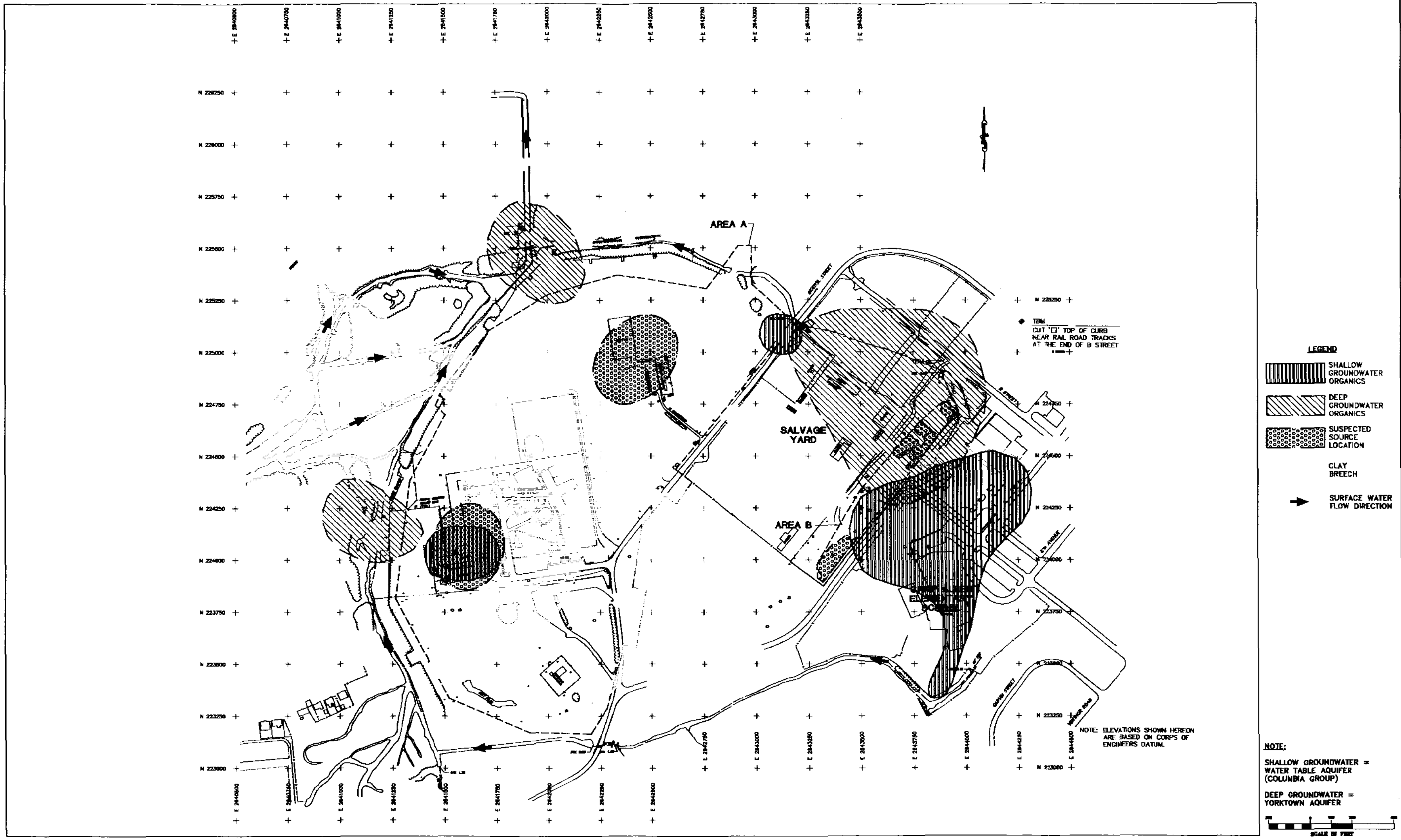
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

GENERALIZED AREAS OF SEDIMENT AND SURFACE WATER ORGANIC AND INORGANIC CONSTITUENTS

SCALE GRAPHIC DATE 7/93

FIGURE 3-3



REVISIONS	
DATE	7/93
SCALE	GRAPHIC
DRAWN	GLB
REVIEWED	DEW
S.O.#	19084
CADD#	084-519

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

GENERALIZED AREAS OF GROUNDWATER CONTAMINATION IN SHALLOW AND DEEP GROUNDWATER

SCALE GRAPHIC DATE 7/93

FIGURE 3-4

4.0 BASELINE RISK ASSESSMENT RESULTS

A comprehensive, quantitative human health evaluation and an ecological evaluation, including the assessment of chemical results from all the media sampled, have been performed for the Camp Allen Landfill Site. The public health portion of the baseline RA assesses Areas A and B of the Camp Allen Landfill separately because the separate landfills result in two distinct areas of contamination. Area A encompasses the western portion of the Camp Allen Landfill. This area was used for the disposal of municipal, solid, and hazardous wastes from the early 1940s until 1975. The Glenwood Park neighborhood (residential area) is situated to the west of Area A. Numerous Glenwood Park residents are serviced by nonpotable residential wells for uses such as lawn watering and car washing. A residential well survey and analytical testing of these wells were conducted to evaluate the potential affects of the landfill on well water quality. The eastern portion of the Camp Allen Landfill (Area B) received wastes from a 1971 Salvage Yard fire. The Camp Allen Salvage Yard, which is currently active, separates the two landfill areas. Figure 4-1 presents Landfill Areas A, B, and the residential area which are of interest in the baseline RA. Landfill Area B has been further subdivided. Subdivisions were determined based on the potential current activities within Area B and the potential for human exposure. Area B subunits include the Pond Area and the Camp Allen Elementary School Area.

The risk assessment also evaluates current potential human exposure, as well as future potential human exposure in the event of a base closure and subsequent residential property development. However, base closure at Camp Allen is unlikely and the "Master Plan, Marine Corps Camp Elmore/Fleet Marine Force, Atlantic (MCE/FMFLANT), Norfolk, Virginia," October 1990, states that future development of the landfill will not occur. Furthermore, the Code of Federal Regulations, Volume 40 (40 CFR), Part 258 (EPA Criteria for Municipal Solid Waste Landfills (MSWLFs), Subpart F: "Closure and Post Closure Care") states that following the closure of all MSWLF units, the owner or operator must record a notation on the deed to the landfill facility property. The notation of the deed must in perpetuity notify any potential purchasers of the property that the property has been used as a landfill and that its future use is restricted so that the integrity of the final cover, liner(s) or other components of the containment system are not disturbed. Future potential risk values generated for future residential property development are, therefore, presented as conservative estimates of potential human health effects.

Ecological concerns were also evaluated throughout Areas A and B of the Camp Allen Landfill. Potential ecological effects were evaluated using available sediment and surface water analytical data in conjunction with terrestrial wildlife surveys and the results of a benthic macroinvertebrate study conducted in June of 1993.

4.1 Identification of Chemicals of Potential Concern

Chemicals detected in environmental media sampled during the RI were reevaluated to select COPCs for evaluation in the baseline RA. Chemicals selected as COPCs were retained for quantitative evaluation. Chemicals not selected as COPCs are discussed in the uncertainties section of the baseline RA (Section 7.0).

COPC selection was based on the information provided in the USEPA Region III Technical Guidance on the Screening of Exposure Pathways and Selection of Contaminants of Concern, dated January 1993 (USEPA Region III, 1993) and USEPA's Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989). COPC selection was completed for each environmental medium in Area A, Area B, Area B Pond, and Area B School using analytical data obtained during Rounds 2 and 3 of the RI.

4.1.1 COPC Selection Criteria

Both of the previously mentioned guidances provide a number of criteria by which chemical data can be evaluated. The primary criteria used in selecting a chemical as a COPC at the Camp Allen Landfill included comparison of maximum detected concentrations with USEPA Region III risk-based COPC screening concentrations, as derived in accordance with USEPA Region III Technical Guidance on the Screening of Exposure Pathways and Selection of Contaminants of Concern (USEPA Region III, January 1993), chemical prevalence, and site history.

Comparison of maximum detected sample concentrations with COPC screening concentrations was used as the primary selection criterion for chemicals detected in soils, groundwater , and air. Since no sediment COPC screening concentrations have been derived by USEPA Region III, residential soil COPC screening concentrations were applied as a secondary criterion for chemicals detected in sediments. Likewise, no surface water COPC screening concentrations are available for comparison with detected surface water concentrations. Comparison with USEPA's ambient water quality criteria derived for the protection of human health was the primary criterion for surface water.

The prevalence of a chemical detected in a given environmental medium within a particular area of concern, as well as the history of site-related activities and comparisons to available state and Federal standards and criteria were other selection criteria used in conjunction with Region III COPC screening concentrations.

4.1.2 Chemicals of Potential Concern

Tables 4-1 through 4-3 present comprehensive lists of all COPCs identified in each area of concern and each investigated environmental medium at the Camp Allen Landfill.

4.2 Human Receptors and Exposure Pathways Evaluated

The following receptors were evaluated in the Baseline RA:

- Area A
  - Brig Prisoners
  - Brig Employees
  - Local Children
  - Local Adults
  - Future Adult Residents
  - Future Child Residents
  - Future Construction Workers

- Area B - Pond
  - Adult Workers
  - Future Adult Residents
  - Future Child Residents
  - Future Construction Workers

- Area B - School
  - Local Children
  - Local Adults
  - Future Adult Residents
  - Future Child Residents

A conceptual site model was developed to evaluate primary sources of contamination and associated release mechanisms, secondary sources of contamination and release mechanisms and potential exposure pathways with which the identified receptors may come in contact. Figures 4-2 and 4-3 present the pathways evaluated for Area A receptors and Area B receptors, respectively.

The exposure point concentrations and assumptions used in this assessment represent the reasonable maximum exposure (RME) as defined by the USEPA in the Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), (USEPA, 1989). RME exposure point concentrations were determined by calculating the upper 95th percent confidence limit of the arithmetic mean (95% UCL) or, where the maximum detected value was greater than the UCL, the use of the maximum value, in the estimation of chronic daily intake (CDI). Maximum detected concentrations were used as exposure point concentrations when they were exceeded by 95% UCLs. In addition, conservative (primarily 50 to 95th percentile) exposure input parameters (i.e., consumption rates, inhalation rates, etc.) were used.

4.3 Risk Assessment Results

The risk assessment for the Camp Allen Landfill Site was performed in accordance with USEPA guidelines presented in the Risk Assessment Guidance for Superfund (USEPA, 1989). Risk estimates were derived using conservative exposure inputs, including the reasonable maximum exposure chemical concentrations and upper bound estimates of daily intake. Incremental cancer risk (ICR) and the potential to experience non-cancer adverse effects (i.e., central nervous system effects, kidney effects, etc.), as measured by a hazard index (HI), were evaluated in this assessment. Estimated ICRs were compared to the target risk range of 10^{-4} to 10^{-6}, which the USEPA considers to be safe and protective of public health (USEPA, 1989). The calculated HI was compared to a threshold value of one; below this level, there is minimal potential to experience non-cancer adverse health effects. In addition, potential ecological effects were evaluated qualitatively.

4.3.1 Total Site Risk

Risk results from each logical exposure pathway were summed for each receptor to determine the total site risk posed by the Camp Allen Landfill. The following paragraphs present the potential current and future exposure pathways and the subsequent potential total site risk to humans.

4.3.1.1 Current Potential Receptors and Exposure Pathways

Potential current receptors to COPCs detected in environmental media at the Camp Allen Landfill include:

- Local Adults
- Local Children (ages 6 - 15 years)
- Local Children (ages 0 - 6 years)
- Brig Employees
- Brig Prisoners
- Elementary School Children (ages 6 - 12 years)
- Elementary School Employees

Local adults and older children could potentially access Area A and Area B on a limited basis and contact COPCs in ditch surface waters and sediments. Local adults and younger children to the west of Area A could also be potentially exposed to COPCs in shallow groundwater during non-potable use of groundwaters that are drawn from residential area wells. Inhalation of volatilized COPCs in outdoor ambient air is another pathway of potential concern for these receptors.

Civilian brig employees and brig prisoners could also be potentially exposed to COPCs in environmental media in Area A. Brig employees could potentially be exposed to COPCs in surface soils, surface waters and sediments. Prisoners could potentially be exposed, via inhalation, to COPCs in surface soils. Both employees and prisoners are also potentially exposed to volatilized organic COPCs in indoor and outdoor air, as well as COPCs adsorbed onto windblown fugitive dust particulates.

Potential current total site risks to these receptors are presented in Table 4-4. All ICR values fall within USEPA's target risk range of 10^{-6} to 10^{-4}, except those estimated for the Brig employee. The total ICR for the Brig Employee was 6.9×10^{-4}. Dermal contact with Aroclor-1254 in ditch surface water contributed 98 percent of the total ICR. The target risk range represents the range of potential risks that USEPA generally believes to be acceptable. HI values presented in Table 4-4 for current potential human receptors fall below 1.0, indicating that noncarcinogenic adverse human health risks will not occur.

Two district areas of potential exposure exist in Area B. These are the Pond Area (Area B Pond) and the area surrounding the Camp Allen Elementary School (Area B School). Area B Pond is inaccessible and only authorized military personnel enter the area. Adult workers (Brig Facility employees and prisoners) currently maintain Area B Pond and could contact soils, surface waters, and sediments. Area B School is accessible to both children and adults. Local adults working at the school could potentially contact COPCs in soils, surface waters and sediments through maintenance activities. Children attending the school could also contact these media.

Table 4-5 presents the current potential total site risk values for human receptors in Area B. The total site ICR values fall within USEPA's target risk range for each Area B receptor, except for the adult worker in Area B Pond. The total ICR estimated for the adult worker was 1.2×10^{-4}. However, total ICRs estimated for each medium were within or below USEPA's target risk range. HI values fall below 1.0 suggesting that current potential noncarcinogenic adverse health effects will not occur subsequent to Area B exposure.

4.3.1.2 Future Potential Receptors and Exposure Pathways

Property use at the Camp Allen Landfill will remain the same in the foreseeable future. Future residential development of the Camp Allen Landfill is highly unlikely. However for the sake of conservatism, future residential development and associated potential risks were evaluated. The potential human receptors evaluated under the future scenarios were:

- Future resident adults
- Future resident children
- Future construction workers.

Tables 4-6 and 4-7 present the total ICR and HI values for the future potential residential development of Area A and Area B, respectively. Future potential adults and children residents could be exposed to COPCs in soils, surface waters and sediments. Future development of Area A and Area B shallow or deep groundwaters for potable purposes is unlikely even in the event of future residential development because of the availability of municipal water. Potential potable exposure to COPCs in groundwater was evaluated for the sake of conservatism. In general, ICR values for future resident children and adults exceed USEPA's target risk range because of the presence of vinyl chloride, 1,2-dichloroethane, and total arsenic; HI values for both adults and children were greater than 1.0, suggesting that noncarcinogenic adverse health effects could occur. 4-Methylphenol was the main contributor to the total HIs in groundwater. Use of dissolved inorganic results did not significantly change the ICR value, but slightly reduces the HI results in Area A shallow and deep groundwaters and in Area B shallow groundwater. The use of dissolved inorganic results in Area B deep groundwaters did result in a significant reduction of HI values. HI values in Area B deep groundwaters were reduced to below 1.0.

4.3.2 Ecological Evaluation

The ecological evaluation focused upon three measures of environmental impact from the Camp Allen Landfill: exceedances of state and Federal criteria for surface waters and sediments, the presence and distribution of benthic macroinvertebrates, and a qualitative assessment of terrestrial flora and fauna.

COPCs exceeded Federal criteria and/or State of Virginia Standards in surface waters at sampled locations throughout Areas A and B. Sediment screening values were also exceeded at various locations. These exceedances represent the potential for environmental impacts. Therefore, exceedances were compared with corresponding field data.

Despite exceedances of Federal or state criteria or standards, significant adverse effects on the benthos have not occurred. High populations of organisms were present in the sediment sampled and a variety of taxa were represented. The aquatic communities appeared to be healthy, especially since they are located in urban drainageways.

In addition, results of the ecological evaluation suggest that potential effects on terrestrial receptors resulting from Area A or B were not observed at any location. For an urban area, the terrestrial habitats appear to be diverse, productive, and healthy.

4.3 Summary

A quantitative evaluation of current potential human exposure to COPCs detected in environmental media investigated at the Camp Allen Landfill resulted in total site ICR value in excess of USEPA's target risk range (10^{-6} to 10^{-4}) for Brig employees in Area A who contact Aroclor-1254 in ditch surface waters, and adult workers in Area B. Total risks associated with individual media in Area B did not, however, exceed USEPA's target risk range. In general, the target risk range represents the range of risks that USEPA usually considers to be acceptable. Current potential human exposure did not result in HI value equal to, or exceeding 1.0, indicating that noncarcinogenic adverse human health effects will not occur.

Current property usage at the Camp Allen Landfill will remain unchanged in the foreseeable future. Future potential development of the property in the unlikely event of a base closure would probably be commercial/industrial or recreational because of a deed restriction concerning former landfills. However, future residential property development and potential residential exposure were evaluated for the sake of conservatism in evaluating future potential land use. Total ICR values for future resident adults and children would exceed the target risk range, particularly if on-site shallow and deep groundwaters were developed for potable purposes. Vinyl chloride was responsible for more than 80 percent of the total site ICR values generated for both shallow and deep groundwaters in Area A, and over 95 percent of the total site ICR values to the shallow groundwater in Area B. Arsenic (85 percent) and benzene (90 percent) contributed predominantly to the total ICRs via the ingestion and dermal exposure pathways estimated for Area B deep groundwater.

Total HI values exceeding 1.0 were also derived. The COPCs 4-methylphenol, 1,2-dichloroethene and arsenic contributed approximately 90 percent of the total HI derived for potential potable use of Area A shallow groundwater. Trichloroethene and 1,2-dichloroethene accounted for approximately 70 percent of the total HI for Area A deep groundwater, via the dermal pathway; while unfiltered thallium contributed 99 percent of the total HI via the ingestion pathway.

Total HI values exceeding 1.0 were derived for the future potential residential exposure of children and adults in Area B. The presence of 1,2-dichloroethene, arsenic and manganese in shallow Area B groundwaters accounted for approximately 85 percent of the total HI for ingestion. The presence of 1,2-dichloroethene and trichloroethene in shallow Area B groundwaters accounted for approximately 95 percent of the total HI for the dermal pathway. Dissolved arsenic was not detected in the shallow aquifer; however, dissolved manganese was detected at a concentration contributing 43 percent of the total HI for ingestion. 1,2-dichloroethene contributed approximately 54 percent of the total HI in filtered groundwater. Total HIs of 24 and 15 were calculated for future residential children and adults potentially exposed to COPCs in Area B deep groundwater. For the ingestion pathway, trichloroethene and 1,2-dichloroethene accounted for only 5 percent of the total HI values. For the dermal pathway, these VOCs accounted for over 65 percent of the total HI values. The presence of arsenic and manganese accounted for more than 90 percent of the total HI for both children and adults. Arsenic and manganese were detected at concentrations accounting for about 5 and 90 percent, respectively, of the total HI estimated for ingestion of Area B filtered deep groundwater, suggesting that the presence of arsenic in deep groundwater is related to the suspended solids in the sample.

Future potential exposure by child residents to soils in Area A accounted for an ICR value of 1.2×10^{-4}, which exceeds USEPA's generally acceptable target risk range, due to the presence of arsenic and Aroclor-1260. HI values for future potential child exposure to this medium was 5.9, indicating that the potential for adverse noncarcinogenic health effects may exist. The presence of arsenic and cadmium in Area A soils were responsible for the elevated HI value.

As a result of USEPA's reasonable maximum exposure to potential current and future potential receptors, the following media and associated chemicals were evaluated in support of remedial alternatives in the Feasibility Study. The following chemicals and environmental media were responsible for future potential human health risks:

AREA A

Shallow Groundwater
- 1,2-Dichloroethene
- Vinyl chloride
- Trichloroethene

Deep Groundwater
- Vinyl chloride
- Trichloroethene
- 1,2-Dichloroethene

Soil
- Arsenic
- Cadmium

Sediment
- Arsenic
- Aroclor-1254
- Aroclor-1260

AREA B

Shallow Groundwater
- 1,2-Dichloroethene
- Vinyl chloride
- Trichloroethene

Deep Groundwater
- 1,2-Dichloroethene
- Arsenic
- Benzene

SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF COPCs IDENTIFIED IN AREA A
CAMP ALLEN LANDFILL, NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Chemicals of Potential Concern									
	Surface Soils	Subsurface Soils	Shallow Ground-water(1)	Deep Ground-water	Surface Water	Shallow Sediments	Deep Sediments	Brig Indoor Air	Gas Well Near Brig Air	Outdoor Ambient Air(2)
Volatile Organic Compounds										
Benzene			X	X				X	X	X
Bromomethane								X		X
Chlorobenzene										
Chloroform				X				X		
Chloromethane								X		
1,4-Dichlorobenzene								X		
1,2-Dichloroethane			X	X						
1,1-Dichloroethene										
1,2-Dichloroethene			X	X						
4-Methyl-2-Pentanone			X							
Methylene Chloride			X					X		
Tetrachloroethene			X	X	X					
Toluene		X	X					X	X	
1,1,1-Trichloroethane								X		
Trichloroethene			X	X	X					
1,2,4-Trimethylbenzene								X	X	X
1,3,5-Trimethylbenzene								X		
Benzyl Chloride								X		
Vinyl Chloride			X	X	X					
Total Xylenes					X			X		
Semivolatile Organic Compounds										
Hexachlorobutadiene								X		X
2-Methylphenol			X							
2,4-Dimethylphenol			X							
4-Methylphenol			X							
Bis(2-ethylhexyl)phthalate			X		X					
Bis(2-chloroethyl)ether				X						
Acenaphthene							X			
Pesticides										
Aldrin			X							
alpha-Chlordane					X					
delta-BHC					X					
delta-chlordane										
gamma-BHC (Lindane)										
4,4'-DDD					X					
4,4'-DDE					X	X	X			
4,4'-DDT						X				
Dieldrin		X			X		X			
gamma-Chlordane					X					
Heptachlor Epoxide			X	X	X					

TABLE 4-1 (Continued)

SUMMARY OF COPCs IDENTIFIED IN AREA A
CAMP ALLEN LANDFILL, NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Chemicals of Potential Concern									
	Surface Soils	Subsurface Soils	Shallow Ground-water[(1)]	Deep Ground-water	Surface Water	Shallow Sediments	Deep Sediments	Brig Indoor Air	Gas Well Near Brig Air	Outdoor Ambient Air[(2)]
Polychorinated Biphenyls										
Aroclor-1254		X			X		X			
Aroclor-1260	X	X				X				
Metals										
Aluminum			X		X					
Antimony			X							
Arsenic	X		X	X	X	X	X			
Barium	X		X		X					
Beryllium			X							
Cadmium	X		X	X		X	X			
Chromium	X		X	X		X	X			
Copper	X		X			X				
Lead	X		X	X	X	X	X			
Manganese	X		X	X	X	X	X			
Mercury					X	X	X			
Nickel			X							
Silver					X	X	X			
Thallium	X			X						
Vanadium	X		X	X		X	X			
Zinc					X		X			
Dissolved Metals										
Aluminum										
Antimony										
Arsenic			X	X						
Barium			X							
Beryllium										
Cadmium										
Chromium										
Copper										
Lead			X							
Manganese			X	X						
Mercury										
Nickel										
Silver										
Thallium										
Vanadium										
Zinc										

Notes: (1) Shallow groundwater COPCs identified for the Glenwood residential area include tetrachloroethene and 1,2-dichloroethene.
(2) Outdoor Air COPCs selected for site-wide evaluations.

TABLE 4-2

SUMMARY OF COPCs IDENTIFIED IN AREA B POND
CAMP ALLEN LANDFILL, NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Chemicals of Potential Concern							
	Surface Soils	Subsurface Soils(1)	Shallow Ground-water(1)	Deep Ground-water(1)	Surface Water	Shallow Sediments	Deep Sediments	Outdoor Ambient Air(2)
Volatile Organic Compounds								
Benzene			X	X	X			X
Bromomethane								X
Chlorobenzene			X					
Chloroform				X	X			
Chloromethane								
1,4-Dichlorobenzene			X					
1,2-Dichloroethane			X	X	X			
1,1-Dichloroethene			X					
1,2-Dichloroethene			X	X				
4-Methyl-2-Pentanone								
Methylene Chloride								
Tetrachloroethene			X					
Toluene								
1,1,1-Trichloroethane								
Trichloroethene		X	X	X	X			
1,2,4-Trimethylbenzene								X
1,3,5-Trimethylbenzene								
Benzyl Chloride								
Vinyl Chloride		X	X	X	X	X	X	
Total Xylenes								
Semivolatile Organic Compounds								
Hexachlorobutadiene								X
2-Methylphenol								
2,4-Dimethylphenol								
4-Methylphenol								
Bis(2-ethylhexyl)phthalate			X		X			
Bis(2-chloroethyl)ether			X					
Acenaphthene								
Pesticides								
Aldrin								
alpha-Chlordane								
delta-BHC								
delta-chlordane								
gamma-BHC (Lindane)			X					
4,4'-DDD		X				X	X	
4,4'-DDE						X	X	
4,4'-DDT								
Dieldrin		X	X	X		X		
gamma-Chlordane								
Heptachlor Epoxide			X	X				

TABLE 4-2 (Continued)

SUMMARY OF COPCs IDENTIFIED IN AREA B POND
CAMP ALLEN LANDFILL, NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Chemicals of Potential Concern							
	Surface Soils	Subsurface Soils[1]	Shallow Ground-water[1]	Deep Ground-water[1]	Surface Water	Shallow Sediments	Deep Sediments	Outdoor Ambient Air[2]
Polychorinated Biphenyls								
Aroclor-1254		X				X		
Aroclor-1260	X							
Metals								
Aluminum			X	X	X			
Antimony		X	X	X		X		
Arsenic	X	X	X	X	X	X		
Barium		X	X	X				
Beryllium		X	X	X		X	X	
Cadmium	X		X	X		X	X	
Chromium	X		X	X				
Copper			X	X		X		
Lead			X	X		X		
Manganese	X	X	X	X	X	X	X	
Mercury			X			X		
Nickel			X	X				
Silver						X		
Thallium		X						
Vanadium		X	X	X		X		
Zinc			X		X	X		
Dissolved Metals								
Aluminum								
Antimony			X					
Arsenic			X	X				
Barium								
Beryllium								
Cadmium								
Chromium			X					
Copper								
Lead								
Manganese			X	X				
Mercury								
Nickel								
Silver								
Thallium								
Vanadium			X					
Zinc								

Notes: (1) COPCs selected for all of Area B.
(2) Outdoor Air COPCs selected for site-wide evaluations.

TABLE 4-3

SUMMARY OF COPCs IDENTIFIED IN AREA B SCHOOL
CAMP ALLEN LANDFILL, NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Chemicals of Potential Concern								
	Surface Soils	Subsurface Soils[1]	Shallow Ground-water[1]	Deep Ground-water[1]	Surface Water	Shallow Sediments	Deep Sediments	School Indoor Air	Outdoor Ambient Air
Volatile Organic Compounds									
Benzene			X	X				X	X
Bromomethane									X
Chlorobenzene			X						
Chloroform				X					
Chloromethane									
1,4-Dichlorobenzene			X					X	
1,2-Dichloroethane			X	X					
1,1-Dichloroethene			X						
1,2-Dichloroethene			X	X					
4-Methyl-2-Pentanone									
Methylene Chloride									
Tetrachloroethene			X						
Toluene									
1,1,1-Trichloroethane									
Trichloroethene		X	X	X					
1,2,4-Trimethylbenzene								X	X
1,3,5-Trimethylbenzene									
Benzyl Chloride									
Vinyl Chloride		X	X	X					
Total Xylenes									
Semivolatile Organic Compounds									
Hexachlorobutadiene								X	X
2-Methylphenol									
2,4-Dimethylphenol									
4-Methylphenol									
Bis(2-ethylhexyl)phthalate			X						
Bis(2-chloroethyl)ether			X						
Acenaphthene									
Pesticides									
Aldrin									
alpha-Chlordane									
delta-BHC									
delta-chlordane									
gamma-BHC (Lindane)			X						
4,4'-DDD		X			X				
4,4'-DDE									
4,4'-DDT									
Dieldrin		X	X	X					
gamma-Chlordane									
Heptachlor Epoxide			X	X					

TABLE 4-3 (Continued)

SUMMARY OF COPCs IDENTIFIED IN AREA B SCHOOL
CAMP ALLEN LANDFILL, NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Parameter	Chemicals of Potential Concern								
	Surface Soils	Subsurface Soils[1]	Shallow Ground-water[1]	Deep Ground-water[1]	Surface Water	Shallow Sediments	Deep Sediments	School Indoor Air	Outdoor Ambient Air
Polychorinated Biphenyls									
Aroclor-1254		X							
Aroclor-1260									
Metals									
Aluminum			X	X					
Antimony		X	X	X					
Arsenic	X	X	X	X	X				
Barium		X	X	X					
Beryllium		X	X	X					
Cadmium			X	X					
Chromium	X		X	X					
Copper			X	X					
Lead			X	X	X		X		
Manganese	X	X	X	X	X				
Mercury			X				X		
Nickel			X	X					
Silver									
Thallium		X							
Vanadium	X	X	X	X					
Zinc			X		X				
Dissolved Metals									
Aluminum									
Antimony			X						
Arsenic			X	X					
Barium									
Beryllium									
Cadmium									
Chromium			X						
Copper									
Lead									
Manganese			X	X					
Mercury									
Nickel									
Silver									
Thallium									
Vanadium			X						
Zinc									

Notes: (1) COPCs selected for all of Area B.
(2) Outdoor Air COPCs selected for site-wide evaluations.

TABLE 4-4

TOTAL SITE ICR AND HI VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS, AREA A NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Receptors	Total HI	Total ICR
Local Adults(1)	3.9×10^{-02}	3.1×10^{-05}
Local Children(2)*	3.4×10^{-01}	5.4×10^{-05}
Brig Employees(3)	$1.7 \times 10^{+00}$	6.9×10^{-04}
Brig Prisoners(4)	7.0×10^{-01}	3.0×10^{-06}

Notes: (1) Local adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of shallow groundwater, surface waters, and sediments, as well as inhalation of VOCs in outdoor air.

(2) Local children could potentially be exposed to surface waters, sediments, and shallow groundwaters, as well as inhalation of VOCs in outdoor air. Total site risk values represent potential exposure to surface waters and sediments by older children and total site risk values for younger children potentially exposed to COPCs in residential area shallow groundwater.

(3) Brig employees (civilian) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as the inhalation of VOCs detected in indoor and outdoor air and fugitive dusts.

(4) Brig prisoners could potentially be exposed to COPCs through dermal contact and accidental ingestion of soils, as well as inhalation of VOCs detected in indoor and outdoor air. Prisoners do not generally gain access to the ditches.

* Total HI and ICR values derived by summing the HI and ICR values for younger children (ages 1 to 6 years) and older children (ages 6 to 15 years) potentially exposed to Area A ditch surface waters and sediments.

TABLE 4-5

TOTAL SITE ICR AND HI VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS, AREA B NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Receptors	Total HI	Total ICR
Adult Workers[1]	5.4×10^{-01}	1.2×10^{-04}
Elementary School Children[2]	6.1×10^{-01}	9.8×10^{-06}
Elementary School Workers[3]	2.5×10^{-01}	1.0×10^{-05}

Notes: (1) Adult workers (employees and prisoners) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs in outdoor air, in Area B Pond during maintenance activities.

(2) Elementary school children (6 through 12) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface water, and sediments, as well as the inhalation of fugitive dusts and VOCs in outdoor air, in Area B School.

(3) Elementary school workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as the inhalation of fugitive dusts and VOCs in outdoor air, in Area B School.

TABLE 4-6

TOTAL SITE ICR AND HI VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS, AREA A, SHALLOW WELL LOCATION B-20W*
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Receptors	Total HI	Total ICR
Resident Adults(1)	$2.0 \times 10^{+02}$ ($2.0 \times 10^{+02}$)	8.2×10^{-02} (8.2×10^{-02})
Resident Children(2)	$3.3 \times 10^{+02}$ ($3.2 \times 10^{+02}$)	3.9×10^{-02} (3.8×10^{-02})
Construction Workers(3)	2.9×10^{-02}	1.3×10^{-06}

Notes: Values in parentheses represent risk values derived using dissolved inorganic constituent results for groundwaters.

(1) Future resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of VOCs detected in outdoor air. Potable use of shallow and deep groundwaters were also evaluated. Potential exposure pathways included ingestion, whole body dermal contact, and inhalation of VOCs while showering.

(2) Future resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of VOCs detected in outdoor air, and by the potable use of shallow and deep groundwaters.

(3) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, and the inhalation of fugitive dusts emanating from excavated subsurface soils.

* Total site ICR and HI values presented using shallow well location B-20W since this location was associated with the most elevated risks in Area A.

TABLE 4-7

TOTAL SITE ICR AND HI VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS, AREA B, SHALLOW WELL LOCATION B-MW11A* NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

Receptors	Total HI	Total ICR
Resident Adults[(1)]	$1.6 \times 10^{+01}$ ($9.8 \times 10^{+00}$)	2.3×10^{-02} (2.2×10^{-02})
Resident Children[(2)]	$2.8 \times 10^{+01}$ ($1.8 \times 10^{+01}$)	1.0×10^{-02} (1.0×10^{-02})
Construction Workers[(3)]	6.1×10^{-01}	6.1×10^{-06}

Notes: Values in parentheses represent risk values derived using dissolved inorganic constituent results for groundwaters.

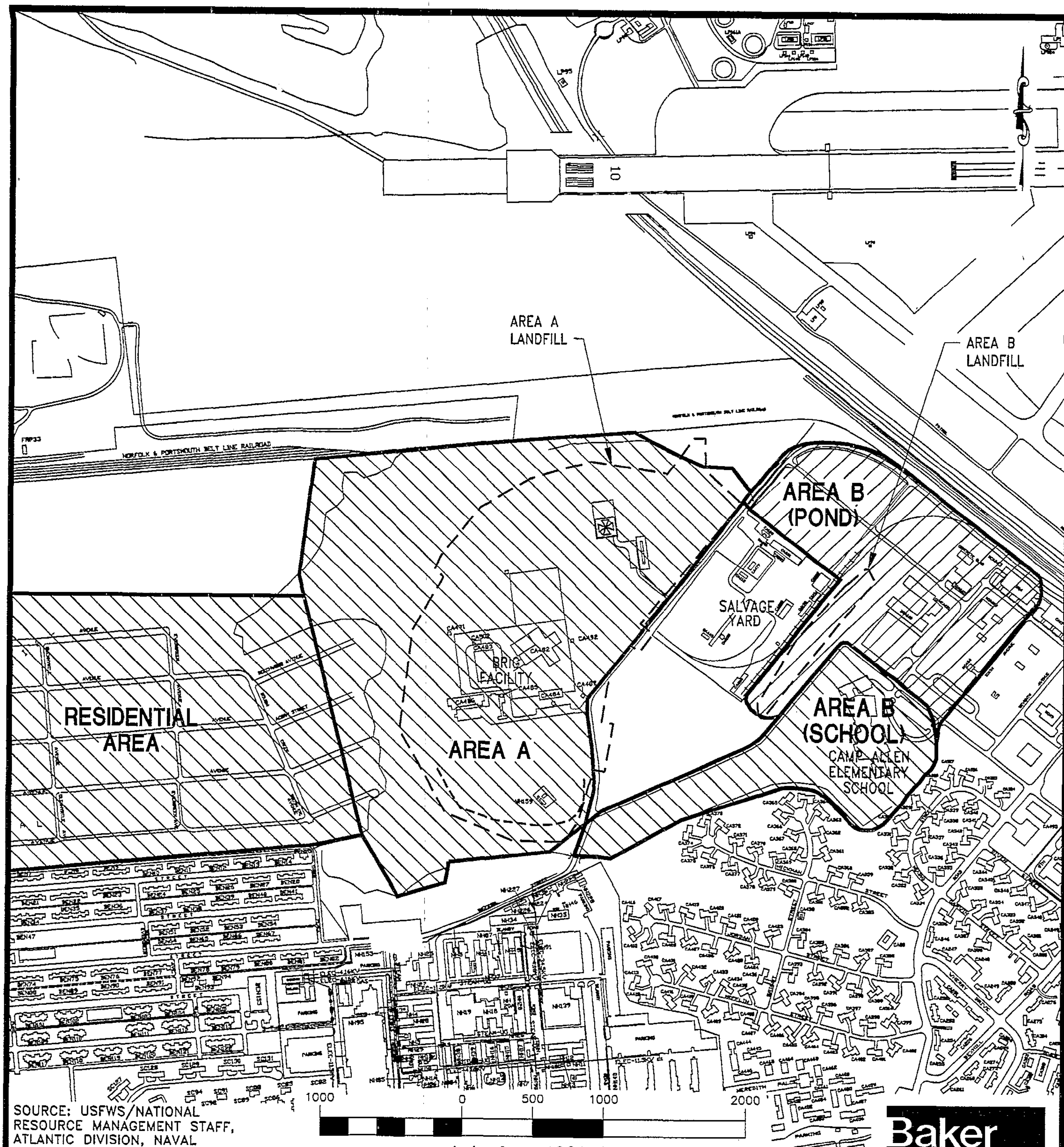
(1) Future resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs detected in outdoor air. Potable use of shallow and deep groundwaters were also evaluated. Potential exposure pathways included ingestion, whole body dermal contact, and inhalation of VOCs while showering.

(2) Future resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs detected in outdoor air, and by the potable use of shallow and deep groundwaters.

(3) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, and the inhalation of fugitive dusts emanating from excavated subsurface soils.

* Total site ICR and HI values presented using shallow well location B-MW11A since this location was associated with the most elevated risks in Area B.

SECTION 4.0 FIGURES



SOURCE: USFWS/NATIONAL RESOURCE MANAGEMENT STAFF, ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND

Baker

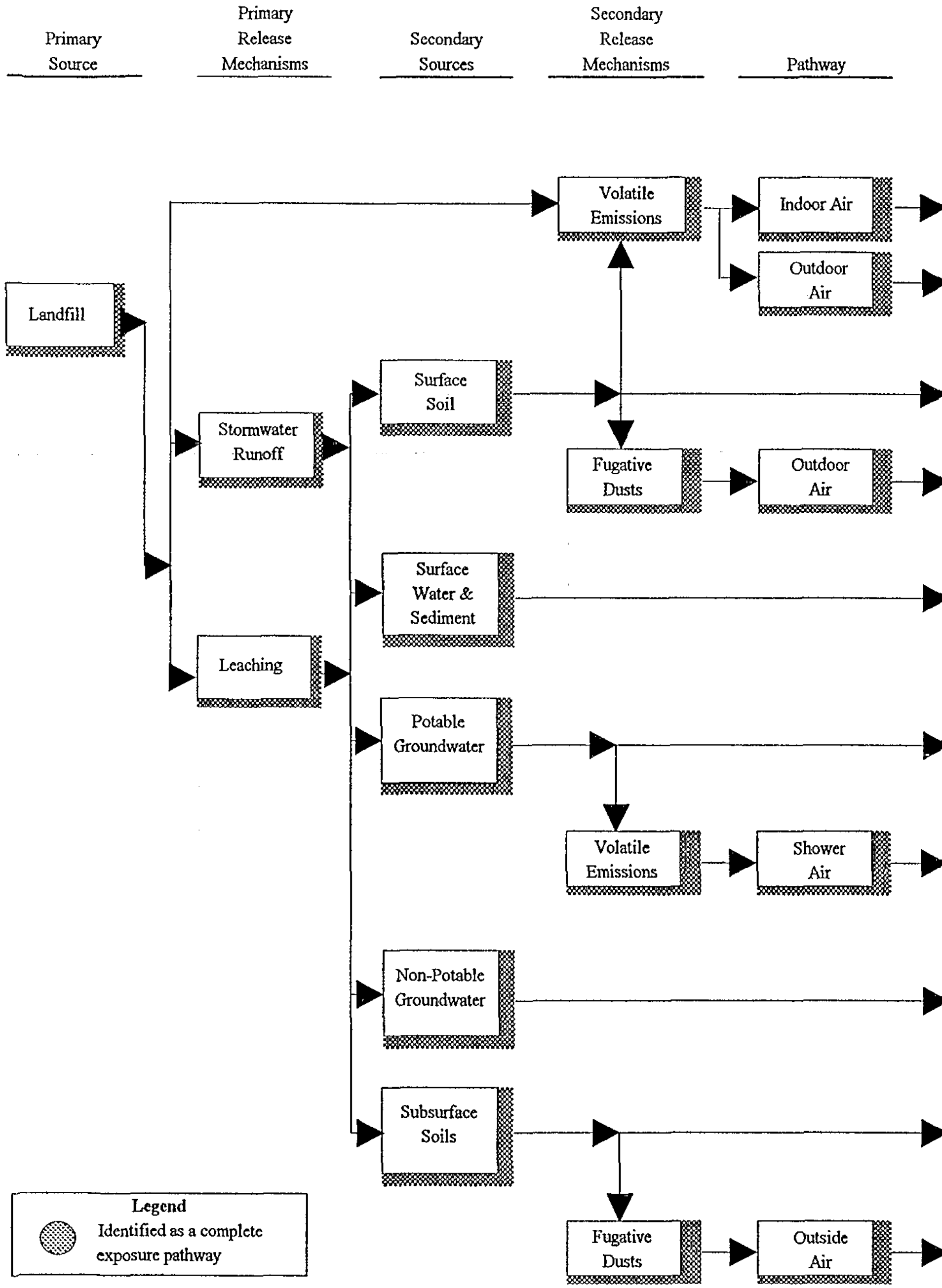
Baker Environmental, Inc.

FIGURE 4-1
IDENTIFICATION OF STUDY AREAS
BASELINE RISK ASSESSMENT
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

084-506

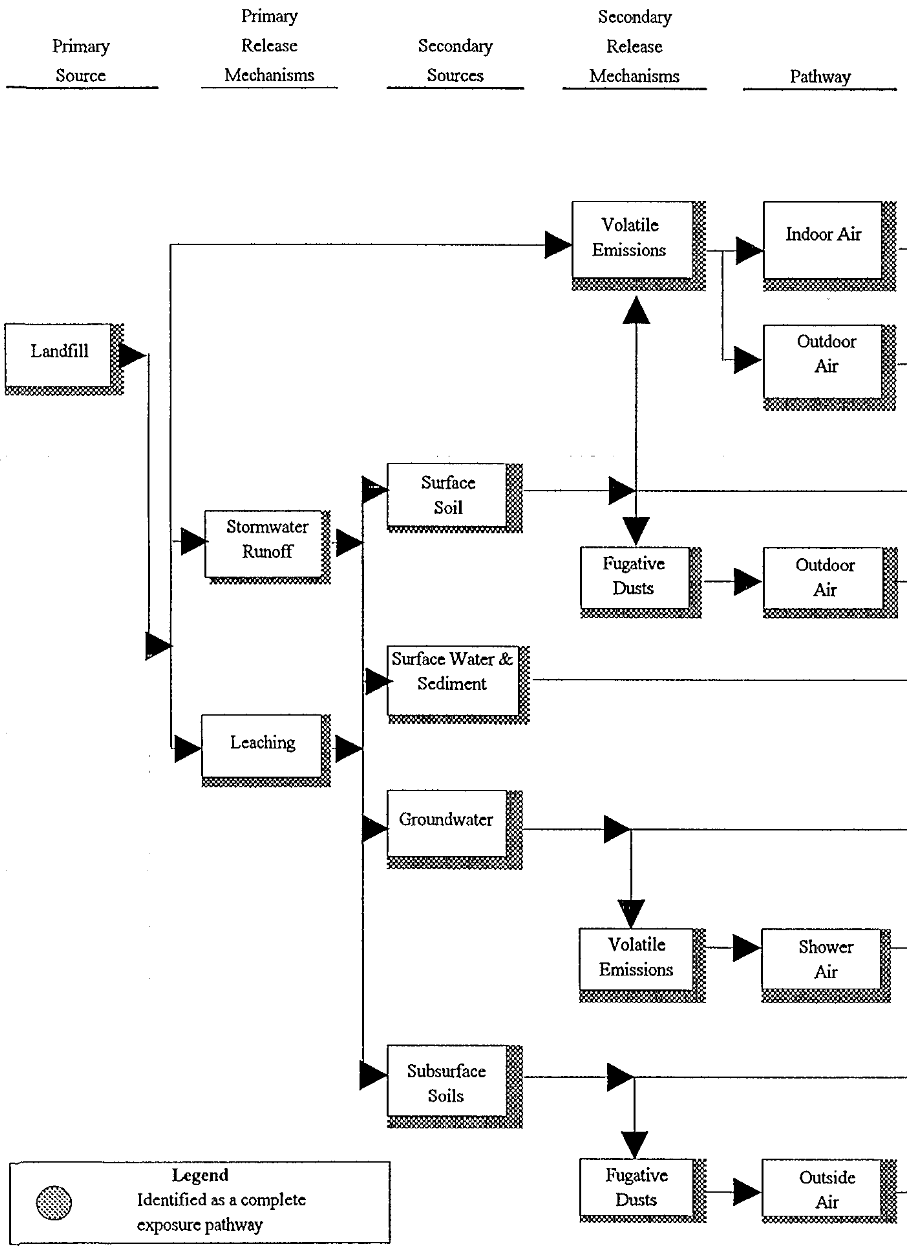
FIGURE 4-2
CONCEPTUAL SITE MODEL
CAMP ALLEN LANDFILL - AREA A
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA



Area A

Exposure Route	Brig Prisoners	Brig Employees	Future Residential Adults	Future Residential Children	Construction Workers	Local Residential Adult	Local Residential Children
Inhalation	●	●					
Inhalation	●	●	●	●		●	●
Ingestion	●	●	●	●			
Dermal Contact	●	●	●	●			
Inhalation	●	●					
Ingestion	●	●	●	●		●	●
Dermal Contact	●	●	●	●		●	●
Ingestion	●	●	●	●			
Inhalation	●		●	●			
Dermal Contact	●		●	●			
Ingestion						●	●
Dermal Contact						●	●
Ingestion					●		
Dermal Contact					●		
Inhalation					●		

FIGURE 4-3
CONCEPTUAL SITE MODEL
CAMP ALLEN LANDFILL - AREA B, AREA B POND, AREA B SCHOOL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA



Exposure Route	Area B Pond: Current Adult Workers	Area B Pond: Future Residential Adults	Area B Pond: Future Residential Children	Area B School: School Employee	Area B School: School Children	Area B School: Future Residential Adult	Area B School: Future Residential Child	Area B: Construction Worker
Inhalation					●	●		
Inhalation	●	●	●	●	●	●	●	
Ingestion	●	●	●	●	●	●	●	
Dermal Contact	●	●	●	●	●	●	●	
Inhalation	●	●	●	●	●	●	●	
Ingestion	●	●	●	●	●	●	●	
Dermal Contact	●	●	●	●	●	●	●	
Ingestion		●	●			●	●	
Inhalation		●	●			●	●	
Dermal Contact		●	●					
Ingestion								●
Dermal Contact								●
Inhalation								●

5.0 FEASIBILITY STUDY OVERVIEW/SITE SUMMARY

The Feasibility Study (FS) for the Camp Allen Landfill Site was conducted according to the basic methodology outlined in the National Contingency Plan (NCP) for interim remedial actions (40 CFR 300.430). The EPA document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988b) was used as a guidance document for preparing this report.

The FS has been based on existing data collected during various studies conducted at the site as documented in this Remedial Investigation (RI) Report. Contamination associated with the Camp Allen Landfill (Area A and Area B) generally consists of volatile organic compounds (VOCs) (e.g., vinyl chloride, toluene) resulting from releases of solvent- and fuel-laden wastes disposed at the site. In addition, other organic and inorganic contaminants were detected; however, the VOCs represent the majority of the risk-based contaminants of potential concern. A risk assessment, documented in Section 4.0 of this report, indicates that there are potential risks to human health or the environment associated with certain media at the Camp Allen Landfill Site.

Based on the RI findings, an Engineering Evaluation/Cost Analysis (EE/CA) for a non-time-critical removal action (Baker, 1993a) in Area B was performed to develop and evaluate alternatives for removal and disposal of contaminated subsurface soil and debris identified in former waste burial trenches at this location. The selected removal action includes:

- Temporary dewatering of the removal areas to lower the water table;

- Collection of extracted groundwater, pretreatment of the water to comply with applicable federal, state, and local pretreatment standards, and transportation to the Hampton Roads Sanitation District (HRSD) wastewater treatment facility for treatment and disposal;

- Excavation of the soil and debris from the trenches plus over-excavation of visibly-contaminated soil from the side walls and floor of the excavation;

- Confirmation soil sampling and analysis, and additional excavation of material contaminated in excess of the removal action endpoints;

- Transportation to and disposal of excavated soil and debris at a RCRA-permitted hazardous waste landfill; and

- Site restoration.

The Area B removal action was initiated in the summer of 1994 and is near completion. At the completion of these activities, the primary sources of contamination at Area B will be eliminated. This removal action has been considered in the FS process.

The FS addresses the following contaminated media at the Camp Allen Landfill Site:

- Area A: VOC-contaminated subsurface soil, inorganic-contaminated surface water/sediment, and VOC-contaminated groundwater.

- Area B: VOC-contaminated subsurface soil, inorganic-contaminated surface water/sediment, and VOC-contaminated groundwater.

As noted in the RI Report, there are additional areas in the immediate vicinity of the Camp Allen Landfill Area with documented or potential contamination of environmental media. The Camp Allen Salvage Yard (CASY) was the subject of a Preliminary Assessment/Site Investigation (PA/SI), and the results were documented in the Final PA/SI Report (Baker, 1994f). In general, CASY activities have included storage and management of waste oils and chemicals, used chemicals, and scrap industrial/commercial equipment. Potential site contamination at the CASY will be addressed during an RI/FS for this site, which is scheduled for 1995.

Based on historical information, the Capehart Housing Area, located south of Area B and the Camp Allen Elementary School, was the site of soil borrow activities during the 1930s and 1940s. During the Camp Allen Landfill RI, potential contamination was identified in this vicinity. Currently, the Navy is further evaluating historical information related to this area in an effort to develop a scope of work for future environmental assessment of the site.

The purpose of this FS was to evaluate a range of remedial alternatives that would protect the public health, welfare, and the environment from potential risks associated with contaminated media at the Camp Allen Landfill Site. The CASY and Capehart areas, and any other potential off-site contamination sources or contaminated media, were not considered or addressed in the FS.

5.1 Remedial Action Objectives

Based on RI findings and the results of the baseline risk assessment, the FS process has emphasized the development of remedial alternatives that meet the following conditions:

- Provide permanent solutions to contamination problems and long-term effectiveness.
- Meet Applicable or Relevant and Appropriate Requirements (ARARs) on a federal level, or a state level if the state requirements are more stringent.

For purposes of the FS, three media of concern have been identified at the Camp Allen Landfill Site as follows:

- Soils
- Surface Water/Sediments
- Groundwater

Remedial action objectives are developed for each medium of concern considering the contaminants of concern, potential receptors, and exposure scenarios.

Given the non-time-critical removal action at Area B, remedial action objectives differ slightly between Areas A and B of the Camp Allen Landfill Site. Remedial action objectives for each area are listed as follows:

Area A

- Soil
    - Prevent exposure to subsurface soil and debris.
    - Minimize migration of contaminants to groundwater and surface water.

- Surface Water/Sediment
    - Prevent exposure to potential contaminants in surface water and sediments.
    - Address indirectly through the development of soil and groundwater alternatives.

- Groundwater
    - Prevent exposure to contaminated groundwater.
    - Prevent further migration of contaminated groundwater.
    - Restore contaminated groundwater.

Area B

- Soil
    - Prevent exposure to subsurface soil and debris.

- Surface Water/Sediment
    - Prevent exposure to potential contaminants in surface water and sediments.
    - Address indirectly through the development of soil and groundwater alternatives.

- Groundwater
    - Prevent exposure to contaminated groundwater.
    - Prevent further migration of contaminated groundwater.
    - Restore contaminated groundwater.

5.2 Cleanup Goal Development

Cleanup goals are developed in the FS for soils and groundwater. Cleanup goals have not been established for surface water/sediments because removal and/or treatment alternatives were not evaluated for site surface water/sediments, as explained in Section 5.3.3.

5.2.1 Soil Cleanup Goals

Soil analytical data obtained during the Camp Allen Landfill investigations indicate the presence of volatile organic compounds (VOCs) in subsurface soils in Areas A1 and A2. Under the influence of infiltrating precipitation, these VOCs may migrate through the unsaturated zone soils to the water table aquifer. Thus, under current conditions, the contaminated subsurface soils in Areas A1 and A2 could potentially act as sources of continuing contamination to underlying groundwater. The objective of soil cleanup goal development is to determine subsurface soil cleanup goals based on the potential for the VOCs to migrate (i.e., leach) to the water table aquifer in Areas A1 and A2 at the Camp Allen Landfill.

A spreadsheet-based transport model described by Summers et al. (USEPA, 1980) was developed to determine the potential soil cleanup goals. The Summers Model is a one-dimensional advective transport model that estimates the potential contaminant concentration in leachate (emanating from the source area) at the top of the water table aquifer. The general input data for the spreadsheet model includes contaminant characteristics, unsaturated zone characteristics, hydrogeological properties of the water table aquifer, and annual precipitation data.

Soil cleanup goals were developed using the Summers Model for the contaminants of concern in Areas A1 and A2. The soil cleanup goals (presented in the FS) were based on attainment of Maximum Contaminant Levels (MCLs) in shallow groundwater immediately below the source area in order to protect the underlying Yorktown Aquifer to its potential future beneficial use (i.e., drinking water supply). Since the MCLs for the contaminants of concern are less than the Federal Ambient Water Quality Criteria and Virginia Water Quality Standards, soil cleanup goals are also protective of surface water.

The soil cleanup goals were used to estimate remediation areas for the FS. It should be noted that, since Area A is a landfill, the primary remedial action objective (RAO) for the soils is groundwater protection rather than soil cleanup. Therefore, achievement of this RAO will not necessarily be based on attainment of the developed soil cleanup goals, but will be based on achievement of groundwater protection, which will be determined through evaluation of actual groundwater monitoring results.

5.2.2 Groundwater Cleanup Goals

Groundwater on site is currently not used for any purpose. The shallow, water table aquifer in the vicinity of the site is generally not suitable for potable (drinking water) use because of naturally high concentrations of iron, manganese and suspended solids, as well as low pH (less than 6). The deeper Yorktown Aquifer is generally suitable for potable uses, except near tidal waters, which can cause the water to be brackish in quality. However, neither the water table or Yorktown aquifers are sources of potable water on site or in the vicinity of the site. Potable water used on site and in the nearby community is supplied by the City of Norfolk, which obtains its water from a number of interconnected surface water sources (i.e., lakes, reservoirs, and rivers) and from several groundwater wells during drought conditions.

Residential wells exist within Glenwood Park, located west of the Brig Facility, but are used for lawn watering, car washing, and filling swimming pools. These wells reportedly are screened within the shallow, water table aquifer. When tested by the Navy for residents of Glenwood Park, none of the wells showed contamination. As a safety precaution, however, the residents in Glenwood Park were advised by the Navy to consider their private wells nonpotable. The deep groundwater (Yorktown Aquifer) in the vicinity of the site is also used for nonpotable purposes. Two active nonpotable wells located approximately 1 mile northwest of the site reportedly pump about 100,000 gallons per day from the Yorktown Aquifer for use as process water.

Cleanup goals for each aquifer have been developed based on the potential beneficial use of the aquifer. For the Yorktown Aquifer, the potential beneficial use is for potable water. Therefore, groundwater cleanup goals were based on state and federal drinking water standards. The Virginia Board of Health MCLs for the contaminants of concern are identical to the federal MCLs. The federal MCLGs are either set at zero or are equal to the MCL for the contaminants of concern.

Therefore, MCLs were used as cleanup goals for the Yorktown Aquifer. However, it is recognized that MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed MCLs. Performance curves will be periodically (e.g., annually) developed and evaluated to monitor groundwater contaminant levels. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be re-evaluated at that time.

Unlike the Yorktown Aquifer, the beneficial use of the water table aquifer is nonpotable use. Nonpotable use cleanup goals were developed for the water table aquifer, and were based on a 1×10^{-6} cancer risk level and a hazard quotient of 1.0 for children and the exposure pathways of incidental ingestion and dermal absorption of contaminants during outdoor activities, such as car washing and lawn watering. Groundwater cleanup goals for both the Yorktown and water table aquifers are presented in the FS.

Groundwater contamination in the Area A region is located in two main areas of the landfill; directly west of the Brig Facility and along the northern portion of the site. For purposes of the FS, these areas were identified as Areas A1 and A2, respectively. Both shallow (water table aquifer) and deep (Yorktown Aquifer) groundwater contamination are present within these areas. The results of the human health risk assessment indicate there would be unacceptable human health risk levels associated with Areas A1 and A2 if either the shallow or deep groundwaters were to be used as a drinking water source.

Groundwater contamination in Area B is located in the vicinity of the landfill, as well as near the southern border of the site, directly south of the Camp Allen Elementary School. The results of the human health risk assessment indicate there would be unacceptable human health risk levels associated with Area B if either the shallow or deep groundwaters were to be used as a drinking water source.

The general approach used for development of groundwater containment and treatment scenarios in the FS was to estimate the downgradient edge of contaminated areas based on available information while making only limited assumptions concerning the upgradient extents of contaminant plumes. In general, the groundwater cleanup levels developed for the organic contaminants were used to estimate the downgradient extents of groundwater defined as "contaminated." The inorganic contaminants detected in the groundwater are believed to be associated with turbidity in the wells and not representative of actual groundwater contamination. The estimated extents of groundwater contamination for the Yorktown and water table aquifers are illustrated in the FS.

5.3 Remedial Action Alternatives

In general, development of remedial action alternatives for the Camp Allen Landfill Site was based on remedial action objectives for each media of concern, as well as on the identification and preliminary screening of remedial technologies and associated process options. The technologies and process options were organized according to the general response actions developed for media of concern at the Camp Allen Landfill Site. Identification and preliminary screening of remedial technologies and associated process options are discussed in detail in the FS.

Detailed analysis of remedial action alternatives was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988b) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), including the February 1990 revisions. In conformance with the NCP, seven of the following nine evaluation criteria were used for the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated by addressing comments received after the FS has been reviewed by the Technical Review Committee (TRC), which includes participants from the Virginia Department of Waste Management and the public.

Remedial action alternatives are discussed in the following subsections by area of the Camp Allen Landfill Site (Area A and Area B) and by media of concern (soil, surface water/sediment, and groundwater).

5.3.1 Area A - Soil Alternatives

The following Area A soil alternatives were developed and evaluated in detail in the FS:

- Alternative A-SO1: No Action
- Alternative A-SO2: Institutional Controls
- Alternative A-SO3: Asphalt/Geosynthetic Cap Over Brig Area with Institutional Controls
- Alternative A-SO4: Composite Cap Over Hot Spot Areas with Institutional Controls
- Alternative A-SO5: In Situ Treatment of Hot Spot Area Soils and Shallow Groundwater Using Dual Phase Vacuum Extraction with Institutional Controls
- Alternative A-SO6: Thermal Treatment of Hot Spot Area Soils with Institutional Controls
- Alternative A-SO7: Disposal of Hot Spot Area Soils in Off-site Hazardous Waste Landfill with Institutional Controls

Alternative A-SO1: No Action

The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination at the Camp Allen Area A Landfill. Groundwater monitoring would be implemented under one of the groundwater alternatives.

Alternative A-SO2: Institutional Controls

Under this alternative, existing institutional controls at Camp Allen (i.e., fences and designation of non-residential areas) would be maintained to limit access and control future use of Area A, as well as to indicate that wastes are buried at the site. Maintenance of existing fencing is proposed under this alternative to restrict access to the landfill and to prevent direct contact with potential buried contamination. If the base were to close in the future, deed restrictions are proposed under this alternative to limit the Camp Allen Landfill to non-residential land uses.

Alternative A-SO3: Asphalt/Geosynthetic Cap Over Brig Area with Institutional Controls

This alternative includes the placement of an asphalt/geosynthetic cap around the Brig Facility area, which is the more active portion of the Area A Landfill, and in the area between the Brig and the western boundary of the landfill The cap would: (1) minimize infiltration of rain water into the waste area, thus reducing leaching and transport of potential contaminants from the soil to groundwater and surface water; and, (2) prevent exposure to potential contaminants within the landfill.. The cap would encompass an area of approximately 12 acres. Construction details are contained in the FS.

In addition, institutional controls as described in Alternative A-SO2 also would be implemented under this alternative to restrict site access and to limit the site to non-residential use.

Alternative A-SO4: Composite Cap Over Hot Spot Areas with Institutional Controls

This alternative includes the placement of a low-permeability composite cap over the "hot spot" areas in Area A1 and A2. The cap would: (1) minimize infiltration of rain water into the waste area, thus reducing leaching and transport of potential contaminants from the soil to groundwater and surface water; and, (2) prevent exposure to potential contaminants within the landfill. The cap would total approximately one acre in size. Cap construction details are presented in the FS.

In addition, institutional controls as described in Alternative A-SO2 also would be implemented under this alternative to restrict site access and to limit the site to non-residential use.

Alternative A-SO5: In Situ Treatment of Hot Spot Area Soils and Shallow Groundwater Using Dual Phase Vacuum Extraction with Institutional Controls

This alternative includes in situ treatment of the "hot spot" or source areas. Approximately 12,814 cubic yards (20,759 tons) of contaminated soil would be treated using a dual phase vacuum extraction (DPVE) system, removing contaminated soil gas and shallow groundwater for subsequent treatment.

Dual phase vacuum extraction is a method to remediate soil and groundwater using only a single extraction system. This method is the most effective method for removing contaminated shallow groundwater when hydraulic conductivities of the shallow aquifers are less than 1.0 gpd/ft^2. The shallow aquifers in Areas A1 and A2 meet this criterion. The system uses high vacuum (>25" Hg vacuum) to strip the vadose zone of VOCs, while simultaneously removing groundwater (in liquid and vapor form) from the shallow aquifer. This two-phase stream is then sent to an air/water separator. The vapor phase is treated using activated carbon. The water stream is intermittently pumped to an on-site groundwater facility or to a collection tank for periodic off-site treatment and disposal. Major components of the DPVE system are described in the FS.

In addition to installation and operation of the DPVE system, institutional controls as described in Alternative A-SO2 also would be implemented under this alternative to restrict site access and to limit the site to non-residential use.

Alternative A-SO6: Thermal Treatment of Hot Spot Area Soils, with Institutional Controls

This alternative includes excavation of the "hot spot" area soils and thermal treatment using either an on-site low temperature thermal treatment unit or off-site incineration. Waste materials not amenable to low temperature treatment, such as buried drums containing spent solvents or waste oil, would be transported to an off-site RCRA-permitted incinerator. Approximately 12,814 cubic yards (20,759 tons) of soil would be excavated using conventional equipment, such as a backhoe, loaded onto trucks, and hauled to a staging area for low temperature thermal treatment. The treated material would be backfilled on site, assuming that the established soil cleanup goals have been met.

In addition to thermal treatment of the contaminated soils, institutional controls as described in Alternative A-SO2 also would be implemented under this alternative to restrict site access and to limit the site to non-residential use.

Alternative A-SO7: Disposal of Hot Spot Area Soils in Off-site Hazardous Waste Landfill with Institutional Controls

This alternative includes excavation of the "hot spot" area soils and off-site disposal in a RCRA-permitted hazardous waste disposal facility. It is assumed that the contaminated soil would be disposed of in an off-site RCRA-permitted hazardous waste landfill without pretreatment. However, if waste materials exceed the RCRA Land Disposal Restriction (LDR) standards (e.g., buried drums containing spent solvents or waste oil) they would be transported to an off-site RCRA-permitted incinerator. Approximately 12,814 cubic yards (20,759 tons) of soil would be excavated using conventional equipment, such as a backhoe, loaded onto trucks, and transported to a RCRA-permitted hazardous waste landfill.

In addition to off-site disposal of the contaminated soils, institutional controls as described in Alternative A-SO2 also would be implemented under this alternative to restrict site access and to limit the site to non-residential use.

5.3.2 Area B - Soil Alternatives

As previously discussed, a removal action is being implemented at the Area B Landfill. At the completion of the removal action, the primary areas of contaminated soil within the landfill will be permanently removed from the site. This removal action will also eliminate the primary sources of groundwater contamination associated with the Area B Landfill. Therefore, alternatives which remove or treat Area B soils are not necessary and were not evaluated in the FS.

The following Area B soil alternatives were developed and evaluated in detail in the FS:

- Alternative B-SO1: No Action
- Alternative B-SO2: Institutional Controls

Alternative B-SO1: No Action

The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination at Area B. Groundwater monitoring would be implemented under one of the groundwater alternatives.

Alternative B-SO2: Institutional Controls

Under this alternative, existing institutional controls at Camp Allen (i.e., fences and designation of non-residential areas) would be maintained to limit access and control future use of Area B as well as to indicate that wastes are buried within the landfill at the site. Maintenance of existing fencing is proposed under this alternative to restrict access to the landfill and to prevent direct contact with potential buried contamination. If the base were to close in the future, deed restrictions are proposed under this alternative to limit these areas to non-residential land uses.

5.3.3 Area A and B Surface Water/Sediment Alternatives

Alternatives that would remove or treat surface water/sediment at the site were not evaluated in the FS for the following reasons:

- Relatively low levels of contaminants were detected in site surface water and sediments.

- Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater).

- Source control measures that are currently being implemented at Area B, and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

- Results of the baseline risk assessment for Area A and Area B surface water and sediment indicate that the only exceedance of human health criteria under the current land uses is a slight exceedance of acceptable levels for brig employees associated with exposure (via ingestion and dermal contact) to surface water in Area A. Under the current land use at Area B (the elementary school), no unacceptable human health effects would be expected from exposure to surface water and sediment.

The following surface water/sediment alternatives were developed and evaluated in detail in the FS:

- Alternative B-SD1: No Action
- Alternative B-SD2: Institutional Controls with Monitoring

Alternative SD1: No Action

The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of surface water/sediment contamination at the Camp Allen Landfill. Groundwater monitoring would be implemented under one of the groundwater alternatives.

Alternative SD2: Institutional Controls with Monitoring

Under this alternative, existing institutional controls at Camp Allen (i.e., fencing and designation of non-residential use areas) would be maintained to limit access and control future use. If the base were to close in the future, deed restrictions are proposed under this alternative to limit these areas to non-residential uses.

In addition, a surface water and sediment monitoring program would be implemented under this alternative to track trends in surface water and sediment contamination at the site. The monitoring program would include semi-annual sampling and analysis of surface water and sediment at approximately 12 locations along the ditches around the site perimeter. For costing purposes, it was assumed that the monitoring program would continue for a five-year period, at which time trends would be evaluated and the need for remedial action or continued monitoring would be assessed.

5.3.4 Groundwater Alternatives

Groundwater alternatives were developed based on the remedial action objectives and general response actions for groundwater, as well as on the remedial technologies and representative process options retained for detailed analysis. As with the soil alternatives, separate groundwater alternatives were developed for Areas A1, A2, and B at the site since these areas represent different regions of groundwater contamination, which have originated from different suspected sources. The groundwater remedial alternatives developed for Areas A1, A2, and B are summarized below.

5.3.4.1 Area A1 Groundwater Alternatives

Area A1 groundwater alternatives developed and evaluated in detail in the FS include:

- Alternative A1-GW1: No Action with Monitoring
- Alternative A1-GW2: Institutional Controls with Monitoring
- Alternative A1-GW3: Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Alternative A1-GW1: No Action with Monitoring

Under this alternative, no actions would be taken to contain or treat contaminated groundwater associated with either the water table or upper Yorktown aquifers in Area A1 at Camp Allen. This alternative would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that seven monitoring wells and three other perimeter monitoring wells associated with Area A1 would be periodically sampled.

Initially, sampling would be conducted on a quarterly basis (i.e., four times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to a semi-annual basis and eventually to an annual basis. Sampling would continue until contaminant levels have decreased below the proposed cleanup goals for several consecutive sampling rounds. For costing purposes, it was assumed that quarterly sampling would be conducted for a 10-year period, followed by a 10-year semi-annual sampling period, and finally by a 10-year period of annual sampling.

Alternative A1-GW2: Institutional Controls with Monitoring

Under this alternative, no actions would be taken to contain or treat contaminated groundwater associated with either the water table or upper Yorktown aquifers in Area A1 at Camp Allen. Existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. Formal institutional controls could also be incorporated into the existing Naval Base "Master Plan." If the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater.

This alternative would also incorporate a groundwater monitoring program as described under Alternative A1-GW1.

Alternative A1-GW3: Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Under this alternative, a groundwater extraction and treatment system would be constructed for the Yorktown Aquifer in Area A1 and operated on site. Operation of a conventional groundwater extraction system in the water table aquifer in Area A1, using wells and submersible pumps, is not feasible because of the aquifer's very low transmissivity. Another technology for remediating shallow groundwater in Area A1, in situ dual phase vacuum extraction, is discussed under Alternative A-SO5 in Section 5.3.1.

The Yorktown Aquifer extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the Yorktown Aquifer. Groundwater would be pumped using a series of mid-depth (approximately 65 feet deep in the Yorktown Aquifer) pumping wells connected to a common treatment system. An estimated groundwater pumping rate of approximately 82 gallons per minute (gpm) would be required to contain the current extent of contamination in Area A1. The conceptual pumping well arrangement, shown in the FS, includes three existing wells each pumping at 5 gpm and three new extraction wells with flow rates ranging from 16 to 27 gpm.

The conceptual extraction system was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. The extraction system design is a containment-type system, designed to contain contaminated groundwater rather than attempt to aggressively restore it to the cleanup goals. With this approach, the groundwater is extracted at a rate equal to the natural flow through the contaminated portion of the Yorktown Aquifer.

The groundwater treatment system included under this alternative has been sized to accommodate groundwater flows from Areas A1, A2, and B. This approach has been taken to achieve an economy of scale by constructing and operating one large treatment system common to all three areas rather than potentially constructing and operating three individual systems, which would be significantly more costly. The estimated groundwater flow rate for Area A1 is 82 gpm. The estimated groundwater flow rates for Areas A2 and B are 82 and 42 gpm, respectively. Thus, the estimated total flow rate for Areas A1, A2, and B is 206 gpm. In order to provide additional capacity for potential future increases in groundwater flow rates, the groundwater treatment system was designed to accommodate a total flow rate of up to 300 gpm.

The primary components of the groundwater treatment system would consist of air stripping and carbon adsorption processes for removal of organic contaminants. A pretreatment system would be used to remove suspended solids and nuisance metals, such as iron, as well as any toxic metals, such as arsenic and chromium, that may be present in the water prior to treatment of the organic contaminants. The pretreatment could consist of equalization, precipitation, flocculation, clarification, and pressure filtration. The pretreatment system would reduce clogging of the air stripper and carbon units, thereby improving their efficiencies and reducing maintenance requirements. Following pretreatment for suspended solids and metals removal, groundwater would be pumped through an air stripper for removal of volatile organic contaminants and then through a carbon adsorption "polishing" process for removal of contaminants not removed by the air stripper.

The treated groundwater would be discharged to the on-site drainage ditch located along the northern boundary of Area A.

Contaminated air generated by the air stripper would be treated, if necessary, to comply with the Virginia Air Emission Standards for Toxic Pollutants (VR 120-04-0301). A comparison of estimated air emission concentrations to these standards indicates that the air emissions would comply with the exemption requirements of VR 120-04-0301, and therefore, treatment of the air stripper off-gas would not be required.

Under this alternative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen, as described under Alternative A1-GW2. Additionally, this alternative would incorporate a groundwater monitoring program as described under Alternative A1-GW1.

5.3.4.2 <u>Area A2 Groundwater Alternatives</u>

Area A2 groundwater alternatives developed and evaluated in detail in the FS include:

- Alternative A2-GW1: No Action with Monitoring
- Alternative A2-GW2: Institutional Controls with Monitoring
- Alternative A2-GW3: Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring.

Alternative A2-GW1: No Action with Monitoring

Under this alternative, no actions would be taken to contain or treat contaminated groundwater associated with either the water table or upper Yorktown aquifers in Area A2 at Camp Allen. This alternative would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that seven monitoring wells at Area A2 and three other perimeter monitoring wells would be periodically sampled.

Initially, sampling would be conducted on a quarterly basis (i.e., four times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to a semi-annual basis and eventually to an annual basis. Sampling would continue until contaminant levels have decreased below the proposed cleanup goals for several consecutive sampling rounds. For costing purposes, it was assumed that quarterly sampling would be conducted for a 10-year period, followed by a 10-year semi-annual sampling period, and finally by a 10-year period of annual sampling.

Alternative A2-GW2: Institutional Controls with Monitoring

Under this alternative, no actions would be taken to contain or treat contaminated groundwater associated with either the water table or upper Yorktown aquifers in Area A2 at Camp Allen. Existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. Formal institutional controls could also be incorporated into the existing Naval Base "Master Plan." If the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater.

This alternative would also incorporate a groundwater monitoring program as described under Alternative A2-GW1.

Alternative A2-GW3: Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Under this alternative, groundwater from the Yorktown Aquifer in Area A2 would be extracted and treated on site. Operation of a conventional groundwater extraction system in the water table aquifer in Area A2, using wells and submersible pumps, is not feasible because of the aquifer's very low transmissivity. Another technology for remediating shallow groundwater in Area A2, in situ dual phase vacuum extraction, is discussed under Alternative A-SO5 in Section 5.3.1.

The Yorktown Aquifer extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the Yorktown Aquifer. Groundwater would be pumped using a series of mid-depth (approximately 65 feet deep in the Yorktown Aquifer) pumping wells connected to a common treatment system. An estimated groundwater pumping rate of approximately 82 gallons per minute (gpm) would be required to contain the current extent of contamination in Area A2. A conceptual pumping well arrangement for Area A2 is shown in the FS.

The conceptual extraction system was based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. The extraction system design is a containment-type system, designed to contain contaminated groundwater rather than attempt to aggressively restore it to the cleanup goals. With this approach, the groundwater is extracted at a rate equal to the natural flow through the contaminated portion of the Yorktown Aquifer.

As described under Alternative A1-GW3, extracted groundwater would be pumped to a groundwater treatment system that is sized to accommodate flows from Areas A1, A2, and Area B. This approach has been taken to achieve an economy of scale by constructing and operating one large treatment system common to all three areas rather than potentially constructing and operating three individual systems, which would be significantly more costly. The estimated groundwater flow rates for Areas A1 and B are 82 and 42 gpm, respectively. Thus, the estimated total flow rate for Areas A1, A2, and B is 206 gpm. In order to provide additional capacity for potential future increases in groundwater flow rates, the groundwater treatment system was designed to accommodate a total flow rate of up to 300 gpm.

The primary components of the groundwater treatment system would consist of air stripping and carbon adsorption processes for removal of organic contaminants. A pretreatment system would be used to remove suspended solids and nuisance metals, such as iron, as well as any toxic metals, such as arsenic and chromium, from the water prior to treatment of the organic contaminants. The pretreatment could consist of equalization, precipitation, flocculation, clarification, and pressure filtration. The pretreatment system would reduce clogging of the air stripper and carbon units, thereby improving their efficiencies and reducing maintenance requirements. Following pretreatment for suspended solids and metals removal, groundwater would be pumped through an air stripper for removal of volatile organic contaminants and then through a carbon adsorption "polishing" process for removal of contaminants not removed by the air stripper. The treated groundwater would be discharged to the on-site drainage ditch along the northern boundary of Area A.

Contaminated air generated by the air stripper would be treated, if necessary, to comply with the Virginia Air Emission Standards for Toxic Pollutants (VR 120-04-0301). A comparison of estimated air emission concentrations to these standards indicates that the air emission would comply with the exemption requirements of VR 120-04-0301, and therefore, treatment of the air stripper off-gas would not be required.

Under this alternative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen, as described under Alternative A2-GW2. Additionally, this alternative would a groundwater monitoring program as described under Alternative A2-GW1.

5.3.4.3 <u>Area B Groundwater Alternatives</u>

Area B groundwater alternatives developed and evaluated in detail in the FS include:

- Alternative B-GW1: No Action with Monitoring
- Alternative B-GW2: Institutional Controls and Monitoring
- Alternative B-GW3: Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Alternative B-GW1: No Action with Monitoring

Under this alternative, no actions would be taken to contain or treat contaminated groundwater associated with either the water table or upper Yorktown aquifers in Area B at Camp Allen. This alternative would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that, on average, ten monitoring wells would be periodically sampled at Area B.

Initially, sampling would be conducted on a quarterly basis (i.e., four times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to a semi-annual basis and eventually to an annual basis. Sampling would continue until contaminant levels have decreased below the proposed cleanup goals for several consecutive sampling rounds. For costing purposes, it was assumed that quarterly sampling would be conducted for a 10-year period, followed by a 10-year semi-annual sampling period, and finally by a 10-year period of annual sampling.

Alternative B-GW2: Institutional Controls with Monitoring

Under this alternative, no actions would be taken to contain or treat contaminated groundwater associated with either the water table or upper Yorktown aquifers in Area B at Camp Allen. Existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. Formal institutional controls could also be incorporated into the existing Naval Base "Master Plan." There are currently no plans to close Camp Allen. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater.

This alternative would also incorporate a groundwater monitoring program as described under Alternative B-GW1.

Alternative B-GW3: Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Under this alternative, groundwater from the water table aquifer and Yorktown Aquifer in Area B would be extracted and treated on site. The extraction system would be used to contain groundwater contaminated above the respective cleanup goals developed for the water table and Yorktown aquifers. Groundwater would be pumped using a series of shallow (approximately 25 feet deep in water table aquifer) and mid-depth (approximately 65 feet deep in Yorktown Aquifer) pumping wells connected to a common treatment system. An estimated groundwater pumping rate of approximately 42 gpm would be required to contain the current extent of contamination in Area B. A conceptual pumping well arrangement for Area B is shown in the FS.

The conceptual extraction system was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. The extraction system design is a containment-type system, designed to contain contaminated groundwater rather than attempt to aggressively restore it to the cleanup goals. With this approach, the groundwater is extracted at a rate equal to the natural flow through the contaminated portions of the shallow and deep aquifers.

As described under Alternative A1-GW3, extracted groundwater would be pumped to a groundwater treatment system that is sized to accommodate flows from Areas A1, A2, and Area B. This approach has been taken to achieve an economy of scale by constructing and operating one large treatment system common to all three areas rather than potentially constructing and operating three individual systems, which would be significantly more costly. The estimated groundwater flow rate for both Area A1 and Area A2 is 82 gpm (total of 164 gpm). Thus, the estimated total flow rate for Areas A1, A2, and B is 206 gpm. In order to provide additional capacity for potential future increases in groundwater flow rates, the groundwater treatment system was designed to accommodate a total flow rate of up to 300 gpm.

The primary components of the groundwater treatment system would consist of air stripping and carbon adsorption processes for removal of organic contaminants. A pretreatment system would be used to remove suspended solids and nuisance metals, such as iron, as well as any toxic metals, such as arsenic and chromium, from the water prior to treatment of the organic contaminants. The pretreatment could consist of equalization, precipitation, flocculation, clarification, and pressure filtration. The pretreatment system would reduce clogging of the air stripper and carbon units, thereby improving their efficiencies and reducing maintenance requirements. Following pretreatment for suspended solids and metals removal, groundwater would be pumped through an air stripper for removal of volatile organic contaminants and then through a carbon adsorption "polishing" process for removal of contaminants not removed by the air stripper. The treated groundwater would be discharged to the on-site drainage ditch along the northern boundary of Area A.

Contaminated air generated by the air stripper would be treated, if necessary, to comply with the Virginia Air Emission Standards for Toxic Pollutants (VR 120-04-0301). A comparison of estimated air emission concentrations to these standards indicates that the air emission would comply with the exemption requirements of VR 120-04-0301, and therefore, treatment of the air stripper off-gas would not be required.

Under this alternative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen, as described under Alternative B-GW2. Additionally, this alternative would incorporate a groundwater monitoring program as described under Alternative B-GW1.

5.4 Comparison of Remedial Action Alternatives

5.4.1 Comparison of Area A Soil Alternatives

A side-by-side comparison of the alternatives for addressing contaminants in Area A soils, based on the seven evaluation criteria, is presented in Table 5-1 With respect to surface soils, all alternatives would essentially provide a similar level of protection to human health and the environment, since little contamination was detected and potential risks to human health are within acceptable levels. With respect to subsurface soils, Alternative A-SO5 would treat the subsurface soil and shallow groundwater in situ, but Alternate A-SO6 would provide the maximum level of protection through removal and active treatment of the potential hot spot(s).

5.4.2 Comparison of Area B Soil Alternatives

A side-by-side comparison of the alternatives for addressing Area B soils, based on the seven evaluation criteria, is presented in Table 5-2. With respect to surface soils, all alternatives would essentially provide a similar level of protection to human health and the environment, since little contamination was detected and potential risks to human health are within acceptable levels. A removal action is being implemented to remove the primary sources of groundwater contamination within the Area B landfill. Therefore, both alternatives would provide the same level of groundwater protection following the removal action. With respect to subsurface soils, Alternative B-SO2 would provide a higher level of protection against possible exposures to potential residual contamination remaining in the landfill through institutional controls.

5.4.3 Comparison of Surface Water/Sediment Alternatives (Areas A and B)

A side-by-side comparison of the alternatives for addressing site surface water/sediments, based on the seven evaluation criteria, is presented in Table 5-3. With respect to surface water/sediments, Alternative SD1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative SD2 would provide a higher degree of protection through institutional controls. In addition, a surface water and sediment monitoring program would be implemented under Alternative SD2 to track trends in contaminant levels over time in these media. For both alternatives, source control measures that are currently being implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment over time.

5.4.4 Comparison of Area A1 Groundwater Alternatives

A side-by-side comparison of the alternatives for addressing contamination in Area A1 groundwater is presented in Table 5-4. Alternatives A1-GW1 and A1-GW2 would not contain or treat contaminated groundwater. Alternative A1-GW3 would achieve protection of the Yorktown Aquifer for beneficial use through extraction and treatment. All alternatives currently provide on-site protection of human health, since groundwater is not currently used on site. Alternatives A1-GW2 and A1-GW3 also would provide protection of human health through institutional controls.

5.4.5 Comparison of Area A2 Groundwater Alternatives

A side-by-side comparison of the alternatives for addressing contamination in Area A2 groundwater is presented in Table 5-5. Alternatives A2-GW1 and A2-GW2 would not contain or treat contaminated groundwater. Alternative A2-GW3 would achieve protection of the Yorktown Aquifer for beneficial use through extraction and treatment. All alternatives currently provide on-site protection of human health, since groundwater is not currently used on site. Alternatives A2-GW2 and A2-GW3 also would provide protection of human health through institutional controls.

5.4.6 Comparison of Area B Groundwater Alternatives

A side-by-side comparison of the Area B groundwater alternatives is presented in Table 5-6. Alternatives B-GW1 and B-GW2 would not contain or treat contaminated groundwater. Alternative B-GW3 would achieve protection of the water table and Yorktown aquifers for their respective beneficial uses through extraction and treatment. All alternatives currently provide on-site protection of human health, since groundwater is not currently used on site. Alternatives B-GW2 and B-GW3 also would provide protection of human health through institutional controls.

SECTION 5.0 TABLES

TABLE 5-1

COMPARISON OF AREA A SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A-SO1 NO ACTION	ALTERNATIVE A-SO2 INSTITUTIONAL CONTROLS	ALTERNATIVE A-SO3 ASPHALT/GEOSYNTHETIC CAP OVER BRIG AREA[1]	ALTERNATIVE A-SO4 COMPOSITE CAP OVER HOT SPOT AREAS[1]	ALTERNATIVE A-SO5 DUAL PHASE VACUUM EXTRACTION OF HOT SPOT AREAS[1]	ALTERNATIVE A-SO6 THERMAL TREATMENT OF HOT SPOT AREAS[1]	ALTERNATIVE A-SO7 OFF-SITE DISPOSAL OF HOT SPOT AREAS[1]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT						
No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. No additional protection from direct contact with potential soil contamination. No additional protection of groundwater.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. No additional protection of groundwater.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls and cap. Partial protection of groundwater provided by cap over Brig area.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls and cap. Partial protection of groundwater provided by cap over hot spot area(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater provided by in situ treatment of source area(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater provided by ex situ treatment of source(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater by off-site disposal of source area(s).
COMPLIANCE WITH ARARS						
No contaminant-, location-, or action-specific ARARs.	No contaminant-, location- or action-specific ARARs.	No contaminant-specific ARARs. Cap designed in accordance with RCRA and state solid waste regulations.	No contaminant-specific ARARs. Cap designed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/ disposed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/disposed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/disposed in accordance with RCRA and state hazardous waste regulations.
LONG-TERM EFFECTIVENESS AND PERMANENCE						
No remedial action would be taken. No reduction in risk levels; however, risks are acceptable under current use, and site is not used for residential use. No additional protection of groundwater.	Institutional actions would administratively limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Maintenance of landfill soil cover effective in limiting surface water infiltration and erosion.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Partial long-term protection of groundwater provided by cap over potential source areas in vicinity of Brig.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Partial long-term protection of groundwater provided by cap over hot spot area(s).	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by in situ treatment.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by ex situ treatment.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by off-site disposal.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT						
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes. Partial reduction in mobility through capping.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes. Partial reduction in mobility through capping.	Reduction in TMV through in situ vacuum extraction/treatment. Effective removal of VOCs, partial removal of SVOCs.	Reduction in TMV through ex situ thermal treatment. Very effective removal of VOCs and effective removal of SVOCs.	No reduction in TMV through treatment. Reduction in mobility via disposal in secure off-site landfill.
SHORT-TERM EFFECTIVENESS						
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Potential risks to human health and environment during operation would be controlled by air emission treatment/ monitoring. Several years required to achieve cleanup levels.	Potential risks to human health and environment during operation would be controlled by air emission treatment/ monitoring. Approx. 6 months required to complete remediation.	Potential risks to human health and environment during excavation would be controlled by dust controls. Approx. 2 months required to complete remediation.
IMPLEMENTABILITY						
Readily implementable.	Straight-forward installation of fencing. Periodic inspection and maintenance of fenced required. Legal/administrative requirements for institutional controls.	Legal/administrative requirements for institutional controls. Capping technologies demonstrated and commercially available. Periodic inspection and maintenance of cap required.	Legal administrative requirements for institutional controls. Capping technologies demonstrated and commercially available. Periodic inspection and maintenance of cap required.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available. Approx. 5-year operation of treatment system.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available. Trial runs may be required. Potential public opposition. Approx. 6-month operation of treatment system.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available.

TABLE 5-1 (Continued)

COMPARISON OF AREA A SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A-SO1 NO ACTION	ALTERNATIVE A-SO2 INSTITUTIONAL CONTROLS	ALTERNATIVE A-SO3 ASPHALT/GEOSYNTHETIC CAP OVER BRIG AREA[1]	ALTERNATIVE A-SO4 COMPOSITE CAP OVER HOT SPOT AREAS[1]	ALTERNATIVE A-SO5 DUAL PHASE VACUUM EXTRACTION OF HOT SPOT AREAS[1]	ALTERNATIVE A-SO6 THERMAL TREATMENT OF HOT SPOT AREAS[1]	ALTERNATIVE A-SO7 OFF-SITE DISPOSAL OF HOT SPOT AREAS[1]
COST						
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $17,557 (annually); $20,000 (every 5 years) NPW: $325,500	Capital: $927,200 O&M: $17,557 (annually); $95,653 (every 5 years) NPW: $1,877,900	Capital: $465,300 O&M: $19,395 (annually); $39,395 (every 5 years) NPW: $819,100	Capital: $490,700 O&M: $108,066 (years 1-4) $139,022 (year 5) $17,557 (years 6-30) NPW: $1,216,700	Capital: $6,141,500 O&M: $17,557 (annually); $37,557 (every 5 years) NPW: $6,467,100	Capital: $9,867,900 O&M: $17,557 (annually); $37,557 (every 5 years) NPW: $10,193,500

[1] Alternative includes Institutional Controls
O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 5-2

COMPARISON OF AREA B SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-SO1 NO ACTION	ALTERNATIVE B-SO2 INSTITUTIONAL CONTROLS
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT	
No unacceptable risks from surface soils for current land uses, marginal risks for future residential use. Provides no additional protection from direct contact, no additional protection of groundwater. However, the removal action of sources at Area B will provide protection.	No unacceptable risks from surface soils for current land uses, marginal risks for future residential use. Provides some additional protection from direct contact by institutional controls, no additional protection of groundwater. However, the removal action of sources at Area B will provide protection.
COMPLIANCE WITH ARARS	
No contaminant-, location-, or action-specific ARARs.	No contaminant-, location- or action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
No remedial action; however, the removal action will provide effective and permanent source removal.	Institutional controls would limit future land use to non-residential. The removal action will provide effective and permanent source control.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT	
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.
SHORT-TERM EFFECTIVENESS	
No risks to human health or environment during implementation.	No risks to human health or environment during implementation.
IMPLEMENTABILITY	
No action; therefore, no implementability concerns.	Periodic inspection and maintenance of fenced required. Legal/administrative requirements for institutional controls.
COST	
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $600 (annually); $20,000 (every 5 years) NPW: $63,200

O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 5-3

COMPARISON OF SURFACE WATER/SEDIMENT ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE SD-1 NO ACTION	ALTERNATIVE SD-2 INSTITUTIONAL CONTROLS WITH MONITORING
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT	
Minor exceedance of risk criteria for exposure to Area A surface water for Brig employees. No unacceptable risks associated with elementary school in Area B. Marginal risks for future residential use. Low levels of contaminants. Migration of contaminants to groundwater not considered to be a pathway. Provides no additional protection.	Minor exceedance of risk criteria for exposure to Area A surface water for Brig employees. No unacceptable risks associated with elementary school in Area B. Marginal risks for future residential use. Low levels of contaminants. Migration of contaminants to groundwater not considered to be a pathway. Provides some additional protection through institutional controls.
COMPLIANCE WITH ARARS	
Minor exceedances of federal and state standards for surface water. No action- or location-specific ARARs.	Minor exceedances of federal and state standards for surface water. No action- or location-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
No remedial action -- risks same as in baseline risk assessment. However, source control actions in Areas A and B are expected to improve surface water/sediment quality over time.	Institutional controls would limit future land use to non-residential. Monitoring would provide information to track contaminant levels in these media.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT	
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.
SHORT-TERM EFFECTIVENESS	
No risks to human health during implementation.	No risks to human health during implementation.
IMPLEMENTABILITY	
No action; therefore, no implementability concerns.	Legal/administrative requirements for institutional controls. Monitoring easily implemented.
COST	
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $50,477 (annually); $70,477 (every 5 years) NPW: $831,600

O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 5-4

COMPARISON OF AREA A1 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A1-GW1 NO ACTION[1]	ALTERNATIVE A1-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE A1-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site.	Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater in the Yorktown Aquifer to established cleanup goals. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds state and federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds state and federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore Yorktown Aquifer to state and federal MCLs. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Periodic groundwater monitoring would effectively track potential contaminant migration.	Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 5-4 (CONTINUED)

COMPARISON OF AREA A1 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A1-GW1 NO ACTION(1)	ALTERNATIVE A1-GW2 INSTITUTIONAL CONTROLS(1)	ALTERNATIVE A1-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT(2)
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: \$0 O&M: \$38,600 (years 1-10) \$19,600 (years 11-20) \$10,100 (years 21-30) \$20,000 (every 5 years) NPW: \$476,700	Capital: \$0 O&M: \$38,600 (years 1-10) \$19,600 (years 11-20) \$10,100 (years 21-30) \$20,000 (every 5 years) NPW: \$476,700	Capital: \$6,108,500 O&M: \$187,300 (yrs 1-10) \$168,300 (yrs 11-20) \$158,800 (yrs 21-30) \$20,000 (every 5 yrs) NPW: \$8,870,200

(1) Alternative includes groundwater monitoring.
(2) Alternative cost includes extraction and treatment system capital cost.
O&M: Operation and maintenance.
NPW: Net present worth.

TABLE 5-5

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION[1]	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE A2-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site.	Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater to established cleanup goals. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds state and federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds state and federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore Yorktown Aquifer to state and federal MCLs. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Periodic groundwater monitoring would effectively track potential contaminant migration.	Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 5-5 (CONTINUED)

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION[1]	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE A2-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[2]
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $59,400 (yrs 1-10) $40,400 (yrs 11-20) $30,900 (yrs 21-30) $20,000 (every 5 yrs) NPW: $796,000

(1) Alternative includes groundwater monitoring.
(2) Alternative cost includes only additional O&M costs for Area A2 groundwater treatment.
O&M: Operation and maintenance.
NPW: Net present worth.

TABLE 5-6

COMPARISON OF AREA B GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-GW1 NO ACTION[1]	ALTERNATIVE B-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE B-GW3 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater, however, groundwater on site and immediately downgradient of contamination is not currently used for any purpose.	Would not contain or treat contaminated groundwater, however, groundwater on site and immediately downgradient of contamination is not currently used for any purpose. Institutional controls would prevent future potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater to established cleanup goals. Contamination below cleanup goals would continue to migrate off site. Groundwater on site and immediately downgradient of contamination is not currently used for any purpose. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds state and federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds state and federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore the water table and Yorktown Aquifers to their respective cleanup goals. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Risks would exceed acceptable levels if shallow or deep aquifers were used for potable use on site. Periodic groundwater monitoring would effectively track potential contaminant migration.	Risks would exceed acceptable levels if shallow or deep aquifers were used for potable use on site. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 5-6 (CONTINUED)

COMPARISON OF AREA B GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-GW1 NO ACTION[1]	ALTERNATIVE B-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE B-GW3 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be treated and monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,1000 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $62,400 (years 1-10) $43,400 (years 11-20) $34,000 (years 21-30) $20,000 (every 5 years) NPW: $842,500

[1] Alternative includes groundwater monitoring.
[2] Alternative cost includes only additional O&M costs for Area B groundwater treatment.
O&M: Operation and maintenance.
NPW: Net present worth.

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